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PINE PLANTATIONS

ON THE

SAND-WASTES OF FRANCE.

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COMPILED BY

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PREFACE.

THE preparation of this volume for the press was undertaken in consequence of a statement in the *Standard and Mail*, a Capetown paper, of the 22nd July, 1876, to the effect that in the estimates submitted to Parliament £1,000 had been put down for the Cape Flats, it was supposed with a view to its being employed in carrying out planting operations as a means of reclaiming the sandy tracts beyond Salt River.

In view of the success which has followed the planting of the Landes of Gascony and the Gironde with the maritime pine, it might seem that nothing now can be required in order to arrest and utilise drift-sands, but to plant them judiciously with that tree. But, happily, I may say, the failure of such plantations on the Landes of La Sologne comes to warn us against any such rash generalisation. And the observation of sand downs in Britain, and sand plains elsewhere, show that herbs, carices, reeds, and grasses have operated extensively in arresting effectually, and, according to their measures, in utilising what otherwise would have been barren and destructive sand-wastes.

Looking at the subject generally, all that I consider established by the pine plantations on the sand-wastes of France is the practicability of arresting and utilising sand-drifts by means of plantations of trees. What has been accomplished there we may legitimately infer may be effected elsewhere, not necessarily by the same means, but by means as appropriate, if they can be discovered. But while this may be all that is established there is much more suggested.

And still more might be found to be suggested by a study of the whole of the sand-wastes of Europe, and of the natural history of sand, its composition, its formation, and its aggregation on the shore, in dunes, in drifts, in sand-wastes, and in sand plains, and of the various genera and species of plants growing upon it, and of planta-

tions of broad-leaved trees which have succeeded in other conditions—the poplar, the willow, and the aspen, the elm, the elder, the ash, the acacia, the oak, the hazel, and the dogwood, the birch, and the wild pear. There has been prepared a twin volume, in which these subjects have been discussed.

This volume was originally compiled in view of what seemed to be required at the Cape of Good Hope. It has been revised, and printed now, only as a contribution towards a renewed enterprise, to arrest and utilise sand-wastes which stretch from Table Mountain to the Hottentot Holland Mountains; and additional information is forthcoming if it should be desired.

Appended to reports of the Colonial Botanist for 1864 is a letter on grasses adapted to arrest drifting sand (pp. 99–102), and appended to report of the Colonial Botanist for 1865 is a letter on the arrest of drifting sand, and planting the same with trees (pp. 83–93).

HADDINGTON, *10th April, 1878.*

PINE PLANTATIONS ON THE SAND-WASTES OF FRANCE.

CHAPTER I.

Appearances Presented by Plantations on Drift Sands.

Within the last eighty years much has been accomplished in the arresting of Drift Sand, and in utilising Sand Wastes by a judicious combination of sylviculture and agriculture.

"A spectator placed on the famous bell tower of the cathedral of Antwerp," says Baude in an article in the *Revue des Deux Mondes*, January, 1859, one of an interesting series of articles entitled *Les Cotes de la Manche*, "saw not long since on the opposite side of the Schelde only a vast desert plain; now he sees a forest, the limits of which are confounded with the horizon. Let him enter within its shades. The supposed forest is but a system of regular rows of trees, the oldest of which is not yet forty years of age. These plantations have ameliorated the climate, which had doomed to sterility the soil where they are planted; while the tempest is violently agitating their tops, the air a little below is still, and sands far more barren than the plateau of La Hague have been formed under their protection into fertile fields."

A similar description of landscape effects, produced by the planting of the Landes of the Gironde in Gascony with pines occurs in Weld's tour through the Pyrenees.

Writing of this district he says:—"Opposite to Blaye, and extending for a considerable distance up and down the Gironde, is the Médoc district, unlovely in appearance, being a vast plain composed of stones and sand, the deposit probably of the river in long past ages. But no smiling valley,

> 'Deep meadowed, happy, fair with orchard lawns,
> And bowery hollows crown'd with summer sea,'

is so fruitful as is this seeming waste: for it is the nursing mother of those vines, which, stunted though they be, produce the far-

famed claret grape. Who, ignorant of these facts, would suppose that an acre of Médoc land is a fortune !"

Writing of Bourdeaux, the capital port of the district, he says :— "Grand indeed is the water avenue to the great city of Bourdeaux. Flowing beneath the softly wooded heights of Floirac, the tawny Garonne, here upwards of 2,000 feet wide, sweeps in a semi-circle past handsome quays three miles long, bearing all kinds of crafts, from the jaunty felucca from the Mediterranean, to the stately Indiaman ; for the tide at Bourdeaux, though the city is seventy miles from the sea, rises twenty feet. Looking at all this beauty and commercial grandeur, I thought of our Thames, and what it might be if properly embanked and provided with capacious quays.

"Long to be remembered is an afternoon which I spent at Floirac, where one of the great wine merchants resides. After an early dinner, consisting of many delicacies, we adjourned, ladies as well as gentlemen, to an arbour in the pleasure ground, situated at the edge of the wooded heights. Within the arbour a large table was covered with an endless variety of delicious fruits, all grown on the estate ; and while we sat round these abundant products of the rich south, the distant views, which are of the most exquisite nature, were illumed by a sunset of great glory.

"On a day remarkable for an extra allowance of caloric—Bourdeaux is exceedingly hot in summer—I visited the far-famed claret vaults of Messrs Barton & Guestier. Oh, how delicious was the wine I tasted in these deliciously cool regions—tasted ! no, drank ; for it would have been nothing short of an insult to that rare old nectar to have acted according to the advice given when you enter the London Dock wine vaults—taste but do not swallow. Here, within the cool precincts of the cellars, if you have the good fortune to be favoured by being allowed to taste famous vintages, you will be made aware how little, how very little, the middle classes really know what good claret is. The stuff which, impudently assuming that name, is generally our potion at a dinner party, is no more like the prime first growth clarets of Médoc than sloe juice and brandy is genuine port ; but when we remember that a hogshead of good claret, the produce of a first-rate vintage, frequently fetches a thousand francs on the spot, we, at least I, who am of the middle classes, can understand that the chance of making acquaintance with prime claret is very small. The more then, if you are a middle man, will you enjoy a tasting visit to the Bourdeaux claret vaults, and especially if you enter them after a lionising tour through streets baked with a temperature of about 90°

. . . Lighted by huge wax candles, I walked long and wonderingly through alleys lined by hogsheads, or *barriques*, as they are called. The value of these, as I was informed, was £120,000. There are generally 10,000 *barriques* in store, for the most part cob-webbed and venerable vessels emitting a peculiar aroma, something like that of new hay; for your first-class claret requires to be kept many years before it is ripe for post-prandial honours."

But sterile as seem the lands of the Médoc, where such treasures are produced, they come short in this respect of the appearance presented by the Landes of the Gironde, which have no such tales to tell of fruit and wine.

"A few miles from Bourdeaux," he writes, "you enter the Landes, across which the line is carried to Bayonne. Nothing can be more dreary than these apparently interminable wastes. Your passage across them suggests ideas of the ocean, with this great difference however, that whereas the latter is rarely at rest, the vast tract of the Landes, comprising 600,000 hectares, equal to 1,482,600 acres, except when swept by hurricanes, presents a still and monotonous surface. The soil is sand—endless sand—vertically as well as superficially. Artesian wells have been sunk to nearly the depth of 1,000 feet, and then a scanty supply of wretched yellow water has been the only result. As may be supposed, the lives of the inhabitants of this unpromising region are short, feverish, and sickly. The Landais have a proverb—

'*Tant que Landes sera Landes*
La pellagri te demande.'

The said *pellagri*, being a fatal disease occasioned by malaria and bad water. Amidst these wastes, lying to the east of the pine forests which fringe the sea coast, the Landais, who are with few exceptions shepherds, spend the long summer days with their flocks of sheep, each animal being as well known to them as their dogs. The Landais shepherd is a primitive being, fond of solitude, rarely venturing near the railway; when he does, he gazes wonderingly at the passing train—so to see him, you must penetrate into his wilderness. There, amidst the great wastes, clothed in sheeps' skins, and wearing the Navarre cap, you will find him mounted on tall stilts, become, from long habit, like a second pair of legs, for he has been accustomed to them from childhood; probably knitting while his flock cross the scanty herbage. There he stands, resting against his pole, a strange tripod-looking figure—stranger still when he strides

across the Landes in hot haste after a wandering sheep. He has a small hut, sometimes a wife who aids him in cultivating a small patch of ground, from which he obtains a little corn and a few vegetables. A miserable existence is this, but the dawn of brighter days has, we may hope, appeared for the poor Landais."

Some two hours journeying by rail takes the traveller from Bourdeaux through clouds of dust and forests of pine to Arcachon. "Here," writes an English tourist, "houses, like Indian bungalows, with broad verandahs, and often of only one storey, run for more than a mile along the water's edge, each surrounded by its own 'compound,' to keep up the Indian phraseology, and each with its bathing-house and steps leading down to the beach. From these the lightly-clad inmates emerge at all hours, and pass the greater part of their time either paddling barefoot on the shore when the tide is out, or dancing in groups in the sea, which has the merit, in the eyes of the nervous part of the population, of always being as smooth as a mill-pond. I never saw a place so absolutely and completely given over to bathing. . . But the real charm of Arcachon lies in its pine forests, covering sand-dunes sometimes three or four hundred feet high, and stretching back over the *landes*, where fresh-water lakes glimmer in the blue distance. Picturesquely grouped within these resinous groves are perched the villas and cottages of the winter town, to which consumptive patients resort in the colder months to breathe turpentine mixed with the soft sea breeze. The extraordinary advantages of this hygienic compound seem to be getting more and more recognised, and each year the number of visitors increases. The high dunes completely shelter the winter town from the violence of the gales, while there is a life and purity in the atmosphere which have worked marvellous results. With a compass one may explore the recesses of these forests for miles on horseback, for there is scarcely any underwood, and one can therefore steer through them in any direction; though in fact there is not much danger of being very seriously lost, for the forest abounds with the wooden shanties of the collectors of turpentine, who are perpetually at work gashing the trees and emptying the little pots tied on to them, and which contain the sap, into the small tanks prepared to receive it. In the centre of the basin are a couple of sand-banks, one of them partially dry at low water, and on which any number of rabbits may be shot; and on the other an oyster-park, with an old hulk stranded upon it. Large parties of merry-makers sail to this moist and oozy spot, and,

taking off their shoes and stockings, catch their own shrimps, gather their own cockles, and knock the oysters off the tiles upon which they are growing, for themselves; and then retiring to the hulk, where sundry articles of diet may be purchased, make their cannibal pic-nic with the addition of these living creatures. . . . Another pleasing entertainment, much resorted to by both sexes, is spearing fish by torchlight. On a dark night the bay is sometimes brightly illuminated with the glare of the pine-splinters flaming from the prows of boats in iron cradles, and the shouts of laughter tell of unsuccessful prods with many-pronged spears at the eels and mullet which wriggle or dart round the bright reflection on the water. It requires considerable skill and practice to bring home a large basketful, but some ladies become tolerably expert at this sport."

And here, amidst all the gaiety of a fashionable watering-place, the residenter or the forester may find a solitude, for which he might seek in vain elsewhere, in the forest of pines. "This, indeed," writes Weld, "is the characteristic feature of Arcachon. The great pine forest of the Landes, locally called *pignadas*, extends from the Adour to the Gironde, and is an extraordinary monument of man's skill and perseverance.

"Prior to 1789 this vast forest area was—

> 'A bare strand
> Of hillocks heaped from ever-shifting sand,
> Matted with thistles and amphibious weeds,
> Such as from earth's embrace the salt ooze breeds.'

The sand was so fine as to be wafted by the faintest breeze; while the great sea storms raised huge sand waves, which overwhelmed vegetation, and, rolling inland, frequently carried desolation and destruction among far distant villages and fields. Such was the state of this part of the country when M. Bremontier, an officer in the Government department of the administration of forests of France, conceived the idea of erecting wattle hurdles and boards near the sea, so as to break the storms; and of sowing in narrow zones, leeward and at right angles to the prevailing wind, seeds of the *Pinus Pinaster* and common broom, in the proportion of five pounds of the former to two of the latter per acre. The area sown was then covered or thatched with pine branches, care being taken to prevent these being blown away, by pinning them to the ground. In about six weeks the broom seeds produced plants six inches high, which attained the height of two feet at the close of the year. These

now afforded excellent shelter to the pine plants, which were but 4-inch striplings, and under their fostering protection the pines grew and flourished, until at length, with an ingratitude not unhappily confined to the vegetable world, they suffocated their infantine protectors, and rose high, defiant of the raging sand-storms.

"So effective was M. Bremontier's process that, in 1871, a commission, appointed by Government to examine the Landes, reported that 12,500 acres were covered with thriving and profitable pines; and the Landais, who had lived to see their howling wastes clothed with far-stretching forests, were enabled to gain a livelihood, less precarious and perilous than that obtained by fishing in the stormy waters of the Biscay Bay.

"Twenty-five years passed, and then the hand of man was busy among the pines. Good as the pinaster is for domestic purposes, La Fontaine says:

'Sera-t-il Dieu, table, ou cuvette?

it is far more valuable for the great quantity of resin, tar, and lamp-black which it produces. As you ride through the pines you will meet the resin-gatherers, *résiniers*, as they are called, who during the summer months live in the forest; for the most part a rude set of men, speaking a strange *patois*, from which, however, you may glean some information. When the resin-harvest is at hand, the *résinier* goes forth provided with a short ladder and a curved axe. His manner of testing the fitness of a tree to be tapped is by throwing his arms around it. If the trunk be so thick that he cannot see his finger ends, the pine is ripe for the operation. This is performed with great quickness and dexterity. A longitudinal cut or groove is made in the trunk, down which the resin flows, and is caught at the bottom of the stem, in a little trough fashioned in a few moments from the bark removed by the cut. Weekly the wound is re-opened but not widened, and the operation is renewed yearly, until the entire trunk is scored in such a manner as to make you wonder how the maimed bole can support the superincumbent weight. But, stranger still, the pine is not injured by this scoring process; for, if the operation be judiciously performed, by the time that the *résinier* has gone round the tree, the first wound has healed, and the trunk is ready to be bled again. Wonderful too is the quantity of resin which exudes from these bountiful trees. You may know where the *résiniers* have lately been, by the palsamic odour proceeding from the wounded pine. A resin-gatherer told me that after a season's practice—from the first of May to the end of September—a good

hand could score 2,400 trees, scrape the *résine molle*, which encrusts the trunks, into the troughs with small iron rakes, and carry the resin to the pits where it is boiled. I saw a *résinier* frequently score a tree to the height of 15 feet, and make a trough in two minutes and a quarter. Such a proficient earns 25 francs weekly, a high wage in this part of France. Indeed, the *résinier* is far better off now than the small vineyard proprietor, who generally, destitute of capital, is ruined by a failure of his crop. . . .

"When the pines have been scored and re-scored, those destined to make tar—called *pins perdus*—are cut down. The tar, commercially known as *goudron des Landes*, not so good, however, as that derived from the Scotch pine, is made by burning the roots and thick portion of the trunk very slowly in cavities made in sloping ground, and the tar is caught in cast-iron pans and run into barrels. An inferior kind of lamp-black is deposited from the smoke of the wood, but a better description is obtained by burning the straw used in straining the resin.

"Besides these products, the resin of the *Pinus Pinaster* yields common turpentine, and is used extensively for pills. Glaring placards and advertisements at Arcachon further inform the visitor that '*Sève de Pin Maritime est recommandée contre les affections de poitrine, catarrhes, bronchitis*,' &c., by the French Faculty,—a revival by the way, in another form, of tar-water, whose varieties were extolled by Bishop Berkeley long ago, in his curious book, entitled '*Sevis*'. . . .

"And even now the economical uses of resin are not exhausted; so the Frenchman did not exaggerate when he asserted that, *résine est l'or en barriques.*

"Many and delightful were the hours that I spent in the Pignadas, generally on horseback, for the country around Arcachon is very favourable for riding, and the small Landais horses are excellent. Arab blood runs in their veins.

"As all the *agrémens* of Arcachon are not yet chronicled in guide books, I may mention that by far the most enjoyable excursion is that to the *Pointe du Sud*, about six miles south of the town. Start early, when the tide is ebbing, so that you may enjoy the fine, broad, hard sand. At the *Pointe du Sud* you have the mighty Atlantic before you, the great Biscayan waves breaking at your feet; while behind dark pines fringe the coast. Return through the forest; avenues, called *Gardes-feu* cut through the pines to prevent the spread of fire, extend to Arcachon; and when you are on the right track, you will

do well not to stray from it, as it is quite possible to realise in these *pignadas* the unpleasant feeling of losing your way, particularly when the sun has set.

"Few places are more impressive than dark pine forests, now screaming when the wind sweeps through to the trees, and now filling the solitude with murmering voices, when stirred by gentle breezes, and yet not a solitude; for as you pass through them in the noontide the air trembles with ceaseless hum. Pines are always a favourite home for insects; and here, in the warm south, they exist in countless multitudes, making even silence vocal; for, flashing through the air, or sluggishly basking in the summer sun, they are endowed with the power of making the forest resonant with strange sounds. By far the most remarkable of these noisy animals is the Cicada, which attains a great size in the pine forests in Southern France, and emits a loud sound, according to my observation, always increasing in intensity as the temperature rises."

Agriculture, as from the first was intended, has followed in the wake of sylviculture.

"After innumerable futile attempts to reclaim and fertilise portions of this desert, two joint stock companies *(Compagnie des Landes*, and *Compagnie d'Arcachon)*, have succeeded in reclaiming a considerable portion of the *Plaine de Cazaux*.

"Sheltered from the prevalent west winds, by the great maritime pine forest, the *Plaine de Cazaux*, situated to the east or leeward, as may be said, of that forest, is not so liable to the destructive effects of the great sand storms as other parts of the *Landes*. Rice, tobacco, and the *topinambour* or Jerusalem artechoke, for which the soil is admirably adapted, are the chief crops. The improvements are in a great measure due to a M. Pierre."

From these pen and ink sketches some idea may be formed of the appearances presented by the pine plantations on the Landes of the Gironde. The forest-like character of these will bear comparison with that of the plantations seen from the tower of the cathedral of Antwerp. And a knowledge of the general appearance presented by the district may lead to the conclusion that the transformation cannot have been less complete.

CHAPTER II.

Appearances Presented by Lands Adjacent to the Pine Plantations in Gascony.

To appreciate aright the effect produced by the planting of the drift sands of the Landes with pine trees, it is necessary to know something of the appearance presented by the land thus utilised, and of the land around which has thus been transformed into what in comparison therewith is a paradise—a garden of delight. A description of the district, which may be reckoned one of the most dreary and dismal in the land, one altogether at variance with the ideas called up by the designation *La Belle France*, is given in a work by Arthur Mangin, entitled "The Desert World," from an English translation, of which I cite the following description:

"The department which borrows its name from the Landes of Gascony is divided by the Adour into two wholly dissimilar parts. To the south of the river lies a rich, undulating, vine-bearing country, rich in pasturage and harvest, sown with pleasant villages and smiling country houses, and watered by full streams and little rivers. To the north the appearance of the country changes abruptly. When the traveller has crossed the alluvial zone of the Adour he sees before him a thin, dry, sandy level of a comparatively recent marine formation. Its only products are rye, millet, and maize; its only vegetation, forests of pines and scattered coppices of oaks; beyond these, and they do not extend far, all cultivation ceases, and the soil is stripped of verdure; you enter upon the Landes—seemingly vast as a sea—occupied by permanent or periodical swamps; and where, over a space of several square leagues, in an horizon apparently boundless, you perceive nothing but heaths, sheepfolds or steadings for the flocks of sheep that traverse these deserts, and shepherds keeping mute watch over their animals, living wholly among them, and having no intercourse with the rest of humanity, except when once a week they seek their masters' houses to procure their supply of provisions. It is these shepherds only (*Landescots* and *Aouillys*), and not, as is generally supposed, all the peasants of the Landes, who are perched upon stilts, so as to survey from afar their wandering flocks, and to traverse more safely the marshes which frequently lie across their path.

"Wild and uncouth are the figures which these stilt-walkers present, as they move rapidly over the country, often at the rate of six or seven miles an hour; occasionally indulging in an interval of rest, by the aid of a third wooden support at the back (curved at the top, so as to fit the hollow of the body), while they pursue their favourite pastime of knitting. The dress of the Landescot is singularly rude. His coat or paletôt is a fleece; cuisses and greaves of the same material protect his legs and thighs; his feet are thrust into sabots and coarse woollen socks, which cover only the heels and instep. Over his shoulder hangs the gourd which contains his week's store of provisions: some mouldy rye-bread, a few sardines, some onions and cloves of garlic, and a flask of thin sour wine. From sunrise to sunset he lives upon the stilts, never touching the ground. Sometimes he drives his flock home at eventide; sometimes he bivouacs *sub jove frigido*, under the cold heaven of night. Unbuckling his stilts, and producing his flint and steel, he soon kindles a cheery fire of fir-branches, and gathering his sheepskins round him, composes himself to sleep; his only annoyances being the musquitoes, and his fears of the evil tricks of wizard or witch, who may peradventure catch a glimpse of him in the moonlight, as they ride past on their besom to some unholy gathering or demon-dance.

"An English traveller has sketched in vivid colours the landscape of the Landes. Over all its gloom and barrenness, he remarks, over all its 'blasted heaths,' its monotonous pine-woods, its sudden morasses, its glaring sand-heaps, prevails a strong sense of loneliness, a grandeur and intensity of desolation, which invests the scene with a sad, solemn poetry peculiar to itself. Emerging from the black shadows of the forest, the pilgrim treads a plain, 'flat as a billiard-table,' apparently boundless as the ocean, clad in one unvaried unbroken garb of dusky heath. Sometimes stripes and ridges, or great ragged patches of sand, glisten in the fervid sunshine; sometimes belts of scraggy young fir trees appear rising from the horizon on the right, and sinking into it again on the left. Occasionally a brighter shade of green, with jungles of willows and water weeds, giant rushes, and 'clustered marish mosses,' will tell of the 'blackened waters' beneath—

> 'Hard by a poplar shook alway,
> All silver-green with gnarléd bark;
> For leagues no other tree doth mark
> The level waste, the rounding gray.'

"The dwellings which stud this dreary, yet not wholly unpoetic

landscape, are generally mere isolated huts, separated oftentimes by many miles. Round them spreads a miserable field or two, planted with such crops as might be expected on a poor soil and from deficient cultivation. The cottages are mouldering heaps of sod and unhewn and unmortared stones, clustered round with ragged sheds composed of masses of tangled bushes, pine-stakes and broad-leaved reeds, beneath which the meagrest looking cattle conceivable find a precarious shelter.

"The Landes are divided into the Little Landes, near Mont-de-Marsan; and the Great Landes, stretching to the north and west of the department of which that town is the capital, and uniting uninterruptedly with those that occupy the vast country situated south of the Gironde. The total superficial area of these plains is estimated at upwards of 2,400,000 acres, of which two-thirds belong to the department of the Landes, and the remainder to that of the Gironde."

Again—"In shape, the Great Landes may be compared to an immense rectangular triangle, having for its base the coast, which, from the mouth of the Gironde to Bayonne, or for a length of more than sixty leagues, is almost rectilineal. But they are separated from the sea by a long parallel chain of lakes and water-courses—a waste of shallow pools—a labyrinth of gulfs and morasses, and then by the continuous chain of the Dunes.

"That which is commonly called the Great Lande is bounded on the north by the *étang*, or lake, of Cazau. It is a sandy, treeless plain, and upon which, for a traject of several leagues from east to west, not one habitation worthy of the name is perceptible until the traveller arrives at Mimizan, near the southern point of the lake of Aureilhan. This lake on the south-west pours its waters into the sea. To the north it communicates, through the canal of St. Eulalie, with the lake of Biscarosse, which is itself connected with that of Cazau. East of this chain of lakes lies the Lande; west of it stretches the range of *Dunes*, or sand hills.

"The lake or pool of Cazau is a small sea of fresh water, perfectly clear, profoundly deep, and fourteen to fifteen thousand acres in extent. It has its whirlwinds and its tempests, so that in certain seasons it is perilous to embark on its surface. And were its banks clothed with rich woods, or raised aloft in irregular or precipitous cliffs, it would surely attract as great a throng of tourists as the mountain-tarns and lochs of Scotland or Cumberland, or the Arcadian waters of Northern Italy. The lake of Biscarosse, in form a triangle, with one side formed by the Dunes, covers about twelve thousand

acres. It derives its name from a village situated at its northern angle, on the bank of the canal which connects it with the lake of Cazau. The lake of Aureilhan is the smallest of the three; the St. Eulalie canal, which links it to the preceding, traverses a series of peat-bogs bounded eastward by gloomy pine-forests, and westward by the interminable Dunes, which, by arresting the flow of the rain-waters, have really created these so-called lakes and extensive swamps. Enormous quantities of rain fall every year in the Landes, —which district the Romans would certainly have dedicated to Jupiter Pluvius,—and find beneath the thin superficial stratum or crust of sand and earth, a sub-soil of *tufa* and *allios*—in other words, of compact chalk and sand agglutinated by a ferruginous sediment. Frequently this *tufa* possesses all the hardness of stone, and its imperviousness is its fundamental property. Hence it follows, that a portion of the heavy annual rainfall remains in the receptacles provided by the hollows and depressions of the soil, and in due time accumulates into marshes and lagoons, until gradually evaporated by the heat of spring.

"When of old the scared peasants beheld the irresistible advance of these strange ministers of destruction, they had no other resource than to fell their woods, abandon their dwellings, and surrender their 'little all' to the pitiless sand and devouring sea. What could avail against such a scourge? Efforts were made to repel it. It is said that Charlemagne, during a brief residence in the Landes, on his return from his expedition against the Saracens, employed his veterans, and expended large sums of money in preserving the cities of the coast from imminent ruin; but whether the means employed were insufficient, or whether the imperial resources failed, and other urgent needs diverted the population and their leaders from this struggle against nature, the works were wholly abandoned."

But in more propitious circumstances the work has been resumed with better success.

"The reader," says the writer I have quoted, "must not believe this country to be a desert in the popular acceptation of the word; it has its forests of pines, where the extraction and preparation of resinous matter are carried on with considerable activity. It has its small towns, its pretty villages, its factories, and even its handsome villas. Finally, modern industry has cut the Landes in two by the Bordeaux railway, which traverses them from north to south, and bifurcates at Morans to throw off a line to Bayonne, and another to Tarbes."

Of the Dunes which have been so transformed M. Mangin gives the following description :—"The Dunes form the extreme line of the Brittany coast for nearly two hundred miles, from the Adour to the Garonne. They are hills of white sand, as fine and soft as if it had been sifted through an hour-glass. Their outline, therefore, changes every hour. When the wind blows from the land, millions of tons of sand are hourly driven into the sea, to be washed up again on the beach and blown inland by the first Biscay gale. A water hurricane from the west will fill up with sand square miles of shallow lake, driving the displaced waters into the interior, dispersing them in shining pools among the 'murmurous pines,' flooding and frequently destroying the scattered hamlets of the people, and inundating their fields of rye and millet.

"Their origin is due to the prevalence of the sea-winds on those points of the coast which are not protected by rock and cliff, and whose slopes of sand descend very gradually to the margin of the waves. Their formation is easily explained. The sand of which they are composed is a silicious material, reduced to minute grains, generally rounded, by trituration. These grains, nevertheless, are often too big and too heavy for the wind to take them up and scatter them afar, like the dust of the highways or the ashes of volcanoes. But at low tide the sand, dried by the sun's rays and the action of the wind, offers to the latter a sufficient *holdfast* to be dragged up the slopes which descend seaward, and deposited at a certain distance. This process being constantly repeated, the heaps are daily increasing in dimensions.

"It will easily be understood that this accumulation along the shore cannot have taken place where the force and direction of the sands experience periodical or capricious changes; for then the sands cast upon the beach by the winds of the north and west would be driven back into the sea by the winds of the south and east. This is noticeable in many places where the nature of the coast is favourable for the production of such a phenomenon. But on other shores—as on the Atlantic littoral of France—the winds which blow most frequently and most violently are from the west and south-west. And it is there we encounter the Dunes. Those of Gascony are by far the most remarkable. Northward, they extend as far as the Point de Grave, which shuts in the mouth of the Gironde; southward, to the bank of the Adour, and even further, to the cliffs of Béarn. Here the basin of Arcachon constitutes one vast hollow; and some openings exist, moreover, in the department of Landes, between that basin

and the Adour, for the overflow of the waters which descend from the interior. To the north and south of the Teste de Buch the chain of sand hills measures from 4,400 to 6,600 feet in width. At other points it is still wider; but it narrows towards its extremities, and both at the Point de Grave and near Bayonne does not exceed 450 yards.

"Owing to their extreme shiftiness of soil, the Dunes can attain no considerable elevation. The sand deposited by the wind on the summit of the hill is always in a state of precarious equilibrium. It has a constant tendency to be precipitated down the other side, and the higher the summit the greater is this tendency, so that there comes at last a moment when no further accumulation in height is possible. The Dune may then extend its basis, may even increase twofold in dimensions, but it no longer rises.

"Let us note, moreover, that owing to its density the sand cannot be carried even by the most violent winds into the higher regions of the atmosphere; and that the Dunes, when they have reached a certain elevation, oppose to them an insuperable obstacle. This circumstance would consequently have a salutary effect, and the accumulation of sand would be determined by a law of its own, if the Dunes, once formed, had time to cohere. But this is not the case. Incessantly does the wind undo or modify its work; and the loftiest hills being the most exposed to its violence, are quickly reduced to the common level. In general, the greatest elevation of the Dunes corresponds to their greatest breadth. Thus the culminating point of those of Gascony is found in the belt situated between the lakes of Cazau and Biscarosse, where the chain is from 7,500 to 9,000 yards across. Their average height is 180 feet to 200 feet above the sea-level; but some of the hills in the forest of Biscarosse attain an altitude of 320 feet. In the neighbourhood of the mouths of the Gironde and the Adour, where the chain is considerably narrowed, the height of the Dunes is only thirty to forty-five feet.

"The reader must not suppose that the Dunes consist of a single series of sand hills ranged along the shore. He will, however, have conjectured, from our statements respecting their width, that they really compose a chain of several more or less regular ridges. The hills are separated from one another by valleys, locally named *laites* or *lettes*. These valleys, where the pluvial waters flow and accumulate, exhibit a striking contrast, in their freshly-blooming verdure, to the naked, barren Dunes. The general aspect of the landscape may, therefore, be compared to that of the ocean. There is the same

broken surface, the same extent of undulation, the billows of sand being upheaved by the wind like the billows of the sea, and sharing in their mobility. You must see, says a writer, in order to form an idea of those colossal masses of fine sand, which the wind incessantly skims, and which travel in this way towards the inland country; you must see their contours so softened that they look like mountains of plaster of Paris polished by the workman's hand, and their surface so mobile that a little insect leaves upon it a conspicuous track; their slopes, at every degree of inclination; their everlasting sterility—not a blade of grass, not an atom of vegetation; their solitude, less imposing than that of the mountains, but still of a truly savage character. You must see, from the summit of one of these ridges, the ocean on your right hand, and on your left the extensive lakes which border the littoral; and, in the midst of this tumultuous sea of tawny sand, green grassy valleys, rich and fertile pastures, smiling oases of verdure, where herds of horses graze, and cows, half-wild, guarded by shepherds scarcely less wild than they.

"The marked characteristic of the Dunes, as we have already said, is their mobility, which renders them a constant menace for the neighbouring populations. To the wind which creates them they owe their frequent changes and their inland movement. While the sea eats into the coast, assisted by the breezes which gradually sweep clear the ground before it, the Dunes extend, and drive before them the shallow lakes: these in their turn encroach upon the Landes, and until now man has been constrained to recoil, step by step, before his threefold enemy. It is in this phenomenon, rather than in the ungrateful soil of the Landes, that we must seek the cause of the curse which has seemed so long to rest upon this country-side. You must go back some twenty centuries to trace the origin of the Dunes of Gascony. Fourteen or fifteen hundred years ago the coast north of the Adour was inhabited, and comparatively flourishing. Mimizan was then a town and a sea-port, from which were exported the resinous products of the neighbouring forests. The Normans disembarked there on several occasions. Under its walls, in 506, was fought a great battle between the allied Goths and Ostrogoths on the one side, and the Béarnais, commanded by a bishop of Lescar, on the other. Both town and port to-day are buried under the sands. 'Full fathom five' lie church and convent, and the busy street, the noisy mart, and the once peaceful home. The present village has nearly perished: the Dune was not three yards from the church when its progress was recently arrested. Other cities, laid down in old charts of the country,

but of which not a trace remains, have in this manner disappeared, and entire forests have been ingulfed, now under the sands of the Dunes, now under the sands and waves of the sea.

"Some parts of the chain have been rendered to a great extent immovable by the vegetation which has gradually covered them, and these have opposed a formidable obstacle to the encroachments of the sands. Yet here and there the barrier has been defied. For example, in the forest of Biscarosse the movable Dunes, actually sweeping over the ancient hills, have not only filled up the valleys, but ingulfed a great number of pines, and raised themselves several yards above the crest of the oldest trees, planted on the summit of the highest hills."

The name *Dunes* is traced etymologically to *Dun*, a hill, and in the designation we may trace the origin of the designation *downs* given to extensive districts in England. The designation *lande* is given to waste lands and moors; and thus may the *landes* of the Gironde be associated in thought with Dartmoor and Exmoor, and with Hownslow Heath and other places bearing similar designations in England.

But if associated in thought differences in their character must not be lost sight of. Of Dartmoor, the extensive and romantic table land of granite, which occupies the south-western part of the country of Devon, it is stated in the work from which I have quoted—"In its recesses still linger the eagle, the bustard, and the crane; its solitudes are broken by the hoarse cries of the sparrow-hawk, the hobby, and the goshawk; and the Cyclopean memorials of Druidism which cover its surface—cromlechs and kistvaens, tolmêns and stone-avenues—invest it with a peculiar air of mysterious awe. It extends in length about twenty-two miles (from north to south), and in breadth twenty miles (from east to west). Its total area exceeds 130,000 acres. It rises above the surrounding country like 'the long, rolling waves of a tempestuous ocean, fixed into solidity by some instantaneous and powerful impulse.' A natural rampart is cast around it. Deep ravines, watered by murmuring streams, diversify its aspect, and lofty hills of granite, locally called *tors*, of which the principal, Yes Tor, has an elevation of 2,050 feet above the sea. Its soil is composed of peat, in some places twenty-five feet deep, underneath which lies a solid mass of granite, occasionally relieved by trap (a volcanic rock), and traversed by veins of tin, copper, and manganese.

"Nearly in the centre of this dismal wilderness lies an immense morass, whose surface is in many places incapable of supporting the lightest animal, and whose inexhaustible reservoirs supply the foun

tains of many a river and stream—the Dart, the Teign, the Taw, the Tavy—all clear as crystal in the summer months, but, after heavy rains, running redly through the 'stony vales.' The roaring of these torrents, when angry and swollen, is sublime to a degree inconceivable by those who have never heard the wild impressive music of untamed Nature.

"The tors are remarkable for their quaint fantastic outlines, which, like the clouds, suggest all manner of strange similitudes—to dragons, and griffins, and hoary ruins, and even to human forms of gigantic size, apparently confronting the traveller as the lords and natural denizens of the rugged waste. The principal summits are Yes Tor, Cawsand Beacon, Fur Tor, Lynx Tor, Rough Tor, Holne Ridge, Brent Tor, Rippen Tor, Hound Tor, Sheep's Tor, Crockern Tor, and Great Mis Tor. Not only must their variety of form delight the artist, but his eye rests well pleased on their manifold changes of colour—purple, and green, and gray, and blue—now softened by a delicate vaporous shadow, now glowing with intense fulness in the sun's unclouded light.

"Dartmoor is traditionally reputed to have been anciently clothed with forest. The sole relic now existing is the lonely *Wistman's Wood*, which occupies a sombre valley, bounded on the one side by Crockern Tor, on the other by Little and Great Bairdown; the slopes being strewn with gray blocks of granite in 'admired disorder,' as if the Titans had been at their cumbrous play. Starting from this chaos of rocks, appears a wood or grove of dwarf weird-looking oaks, interspersed with the mountain-ash, and everywhere festooned about and garlanded with ferns and parasitical plants. None of these trees exceed twelve feet in height, but at the top they spread far and wide, and 'branch and twist in so fantastic and tortuous a manner as to remind one of those strange things called mandrakes.' Their branches are literally covered with ivy and creeping plants, and their trunks so thickly embedded in a coating of moss that at first sight, says Mrs. Bray, 'you would imagine them to be of enormous thickness in proportion to their height. Their whole appearance conveys to you the idea of hoary age in the vegetable world of creation; and on visiting Wistman's Wood it is impossible to do other than think of those "groves in stony places" so often mentioned in Scripture as being dedicated to Baal and Astaroth.'

"That heathen rites were celebrated here in the pre-historic era seems very probable, the best etymologists agreeing that the name is a corruption of *Wise-man*, or *Wish-man*; that is, of the old Norse god

Woden, who is still supposed to drive his spectral hounds across the silent wastes of Dartmoor. Celtic or Cymric memorials, as we have previously hinted, are very abundant and very various. There are cromlechs, where the Britons buried their dead; stone pillars, with which they commemorated their priests and heroes; avenues of upright stones leading up to the circles, where, perhaps, their priests celebrated their religious rites; kistvaens, or stone-chests, containing the body unburned; tolmêns, or holed stones, whose meaning cannot be determined, but which may probably have had some astronomical uses; bridges, huts, and walled villages, all bearing traces of the handiwork of our 'rude forefathers.'"

For the counterpart of this we must go considerably to the north of the Landes; but we find it in Brittany, which, geologically speaking, may be regarded as a prolongation of our English mountains, to which, with all the north-west coast of France, they were formerly united. "Brittany," writes Mangin, "belongs to what geologists call the primitive and intermediary formations. It is divided into three belts or longitudinal trenches: those of the north and south consist of primitive rocks, granite, and porphyry; the central appertains to a more recent formation, to the group of intermediary or secondary rocks, composed in the main of schists and mica-schists, quartz, and gneiss. Schist prevails over a considerable area, and is prolonged to the very extremity of the peninsula. These hard, compact, impervious rocks, are entirely bare in many places; elsewhere, and over a great extent, they are covered but by a thin layer of clayey and sandy earth, where the sudden slopes of the soil do not allow the rains to settle.

"Here are the plains, often of considerable dimensions, which, bristling with rocks, and broken up by ravines, water-courses, and marshes, constitute the Landes of Brittany. True deserts these, relieved at distant points by an isolated hut, or by a wandering herd of swine, lean cows, and meagre-looking horses, which obtain a scanty subsistence from the heathery soil, sown here and there with tufts of furze, broom, and fern.

"Under a sky of almost continual sombreness, like that which impends over the pottery districts of England, these landes present a sufficiently sinister and uninviting aspect. The traveller, as he crosses their sepulchral wastes, will hardly marvel that they were anciently a chosen seat of Druidical worship. Like Dartmoor, they would seem to have offered a peculiarly fitting arena for the rites and ceremonies of a creed which we know to have been mysterious in

character and sanguinary in spirit. They are covered with its gray memorials: the masses of granite of different shapes known as *Maenhirs*, or 'long stones,' and *peulvens*, which appear to have been employed as sepulchral monuments; *dolmens*, or 'table-stones;' and *cromlechs* (*crom*, bowed or bending, and *lech*, a stone), which antiquaries are now agreed to regard as the remains of the ancient cemeteries or burial places. At Camac, near Quiberon Bay, may be seen a truly remarkable example of the *Parallelitha*, or avenues of upright stones, forming five parallel rows, which extend for miles over the dreary moorland. What were their uses it is impossible to determine, for there seems little ground to believe, as some writers would have us believe, that they were 'serpent temples,' where the old Ophite worship was celebrated. We can only gaze at them in wonder: mile upon mile of gray lichen-stained stones, some twenty feet high, laboriously fashioned, and raised in their present places by the hand of man some twenty centuries agone.

"On these very *dolmens*, where the priests of the Tentates were wont to immolate their human victims to their unknown god, the mediæval sorcerers and sorceresses celebrated the Black Mass, or Mass of Satin, in terrible burlesque of the Roman Catholic sacrament, concocted their abominable philtres, and performed their dreary incantations. Alas for human nature! In every age it is a prey to the wildest credulity. Even in the present day more than one superstition hovers around the monuments of the Celtic epoch. The Bretons believe them haunted by demons called *poulpiquets*, who love to make sport of the passing stranger, but will sometimes give both counsel and encouragement to those who know how to address them in the prescribed formulas; who, like the Ladye in the 'Lay of the Last Minstrel,' at their bidding can bow

'The viewless forms of air.'

For, in the Breton mind, the superstitions of Druidism have not been wholly uprooted by the teachings of Christianity, still less by those of science and reason. Many a dark and dismal legend flourishes in the lonely recesses of the landes.

"Brittany, like England, has its *Cornouaille*, or Cornwall, and it is here, particularly in North Cornwall, that we see it under its most desolate aspect, with its chains of black treeless hills covered with heath and furze; with its deserts of broom and fern, its ruins scattered along the winding roads, its attenuated herds wandering at their will across the moors, and its savage, ignorant, and scanty population.

The Bretons of Cornwall, according to a French writer, are elevated but a little above the true savage life. Those who dwell upon the coast live on the products of their fishing, except when the fortunate occurrence of a wreck provides them with temporary abundance. At bottom, they possess the qualities and defects of characters strongly tempered, but absolutely uncultivated. They are as hard and bare as their own granite rocks. Persevering, courageous, resolute, they make excellent sailors, the best which France can find; the sea is for them a second country. Progress, which they do not understand, inspires them with a sort of terror, a gloomy mistrust. When the railway surveyors first intruded upon their solitudes, these rigid conservatives assailed them with volleys of stones, and, when the railroads were laid down, flung beams across the lines to overthrow the hissing, whirring trains which threatened to disturb their prescriptive barbarism. They asked but to be left alone—to be suffered to live as their forefathers lived—to be spared the ingenuities, successes, vices, and virtues of the New World. But modern civilization, like Thor's hammer, or Siegfried's magic sword Balmung, will break down the last barriers raised by ignorance and superstition. It will shed its light upon the wilds and wastes of Brittany, and compel their inhabitants in the course of years to acknowledge its value and accept its benefits."

There is not a little in the ethnological remarks made which I am not prepared to homologate. I consider the Parallelitha and similar erections had no connection with Druidism, that they were more probably connected with the worship of Baal in some of its forms, having their counterpart in the high places spoken of in the Jewish Scriptures, while the Druids represented the worshippers of the "groves." But referring thus to this in passing I gladly, and with gratitude, avail myself of the topographical description.

Ere we reach that stony region in travelling northwards from the Landes of Gascony, we must pass across the peat bogs of Montoir and the Grand Brière, near Savenay, in the department of the Loire Inférieure. They occupy a considerable area of a vast desolate plain, where a few lean sheep crop an insufficient food from the scanty herbage, and whose sole product is turf. "This country," says Jules Janin, "has no other harvest, no other wealth than its peat; neither fruit, nor flowers, nor corn, nor pastures, nor repose, nor well-being; the earth is wild, the sky one of iron. It is a region of stagnant waters, pestiferous exhalations, decrepit men, famished animals."

"The swampy levels of Montoir form the natural vestibule to the Armorican Peninsula, which of all the French provinces has the longest and the most vigorously withstood the advance of civilization, its ideas, and its modern institutions, and has the most rigidly preserved its primitive character. There are many nooks and corners in Brittany scarcely changed in outward aspect or inner life since the remote days when it was a valued appanage of the English crown. They seem to have been plunged in a sleep of centuries, from which the shrill whistle of the steam-engine is only just awakening them. The country is undulating and broken; in the central districts it assumes quite a mountainous character. It is true that its heights are only of moderate elevation, the loftiest not exceeding 2,000 feet; but they are barren, rude, and sombre in appearance. The coast is picturesque enough to delight the most zealous artist, bordered with high and abrupt cliffs, and lined, as it were, with a beach where the waters of the Channel ever break in floods of spray and foam, and where masses of rock lie scattered of immense size and the most fantastic forms."

The counterpart to this we find in the English fen country, which extends inland, around an arm of the North Sea called the Wash, into the six counties of Cambridge, Huntingdon, Lincoln, Norfolk, Northampton, and Suffolk, with an area of upwards of 420,000 acres. Inland it is bounded by an amphitheatral barrier of high lands, and touches the towns of Bolingbroke, Brandon, Earith, Milton, and Peterborough. Into this great basin flow the waters of the greater part of the drainage of nine counties, which gather into the rivers Cam, Glen, Lark, Nene, Great and Little Ouse, Stoke, and Welland, these being linked together by a network of natural and artificial canals.

"Anciently, the Fens were pleasant to the eye of the lover of the picturesque; for they contained shining meres and golden reed-beds, haunted by countless water-fowl, and strange, gaudy insects. 'Dark-green alders,' says Kingsley, 'and pale-green reeds stretched for miles round the broad lagoon, where the coot clanked and the bittern boomed, and the sedge-bird, not content with its own sweet song, mocked the notes of all the birds around; while high overhead hung hawk beyond hawk, buzzard beyond buzzard, kite beyond kite, as far as eye could see.' What strange transformations must this wild region have undergone! There was a time, in all probability, when a great part of the German Ocean was dry land, through which, into a vast estuary between North Britain and Norway, flowed together

all the rivers of North-eastern Europe—Elbe, Weser, Rhine, Scheldt, Seine, Thames, and all the rivers of east England, as far north as the Humber. Meanwhile, the valleys of the Cam, the Ouse, the Nene, the Welland, the Glen, and the Witham, were slowly 'sawing themselves out' by the quiet action of rain and rivers. Then came an age when the lowland was swept away by the biting, corroding sea-wash still so powerfully destructive on the east coast of England, as far as Flamborough Head. 'Wave and tide by sea, rain and river by land; these are God's mighty mills in which he makes the old world new. And as Longfellow says of moral things, so may we of physical,—

> "'Though the mills of God grind slowly, yet they grind exceeding small;
> Though he sit and wait with patience, with exactness grinds he all.'"

These ever-active causes have converted the dry land into the fens. The mud brought down by the rivers cannot get away to sea; and, with the *débris* of the coast, it is constantly swept southward by tide and current, and deposited within the great curving basin of the Wash, between Lincolnshire and Norfolk. There it is kept by the strong barrier of shifting sands coming inwards from the sea; a barrier which also confines the very water of the fens, and spreads it inland into a labyrinth of streams, shallow meres, and bogs. The rainfall, over the whole vast area of dull level, has found no adequate channels of escape for centuries; and hence we may understand how peat—the certain product of standing water—has slowly overwhelmed the rich alluvium, and swallowed up gradually the stately forests of fir and oak, ash and poplar, hazel and yew, which once spread far and wide over the blooming country.

> 'Many a green isle needs must be
> In the deep wide sea of misery,'

sings Shelley; and this dreary outcome of mudbank and bog and mere had its wooded isles, very fair and lovely to behold, redeeming the desolation of the landscape. Such were Ramsey, Lindsey, Whittlesea, whose names remind us of their whilome characteristics (*ea*, *ey*, an island). In these green places the old monks loved to build their quiet abbeys, rearing their herds in rich pastures, feeding fat fish in their tranquil streams, and dreaming in the shadow of green alder and stately ash.

"But these Eden-isles were few, and the surrounding marsh was black and dismal enough to scare the boldest spirit, and pestilential enough to sap and undermine the strongest frame. The Romans had attempted to drain and embank it, and their *vallum* may still be

tracked along the surface of the marsh-lands, marked to this day by the names of Walsoken, Walton, and Walpoole. In the Middle Ages, however, it returned to its primeval desolateness—a waste and wilderness, haunted by the foul legends of an unwholesome superstition. In the immediate neighbourhood of the great monasteries of Crowland and Ely, and of the thriving towns, the good work of drainage went on slowly; but elsewhere the land was given up to the bittern and the heron."

By Dukes of Bedford much was accomplished in the earlier half of the seventeenth century, and by Rennie, the great engineer, some hundred and fifty years later, to fit these fens for agricultural operations. "Works are now in progress," says the writer from whom, in furtherance of my work, I have quoted so largely, "for rescuing a further portion of the basin of the Wash, to be formed into a new county, and named after the Queen. So that now, in tracts once covered by the sea, or knee-deep in reedy, slushy, pestilential slime, the grass grows luxuriantly, the crops wave in golden abundance, or the breeze takes up and carries afar—

'The livelong bleat
Of the thick-fleeced sheep from wattled folds.'

"But the dominion of labour has not yet been established over the the whole Fen-districts. There are still dreary nooks, and gloomy corners, and unproductive wastes; wild scenes there are, which few Englishmen have any conception of as contained within the boundaries of their own 'inviolable isle.' Romantic scenery, remarks Mr. Walter White, must not be looked for on the Lincolnshire coast. In all the journey from the Wash till you see the land of Yorkshire, beyond the Humber, not an inch of cliff will your eyes discover. Monotonous is the prospect of—

'A level waste, a rounding gray'

of sand-hills, which vary but slightly in height, and bristle with *marum*. 'But tame though it be,' continues our authority, 'the scene derives interest from its peculiarity. Strange perspective effects appear in those irregular hills: yonder they run out and form a low dark, purple headland, against which the pale green and yellow of a nearer tongue look bright by contrast. Here for a few furlongs the range rises gray, cold, and monotonous; there it has a warmth of colour relieved by deep shadows, that change their tint during the hours that accompany the sun while he begins and ends his day. Sitting on the summit of those dry hills, you will remark the con-

trasted landscape: on the one side, the level pasture land, league after league of grassy green, sprinkled with villages, farms, churches, and schools, where work and worship will find exercise through ages yet to come; on the other, league after league of tawny sand, sloping gently outwards to meet the great sea that ever foams or ripples thereupon. On the one hand, a living scene bounded by the distant wolds; on the other, a desert, sea and shore alike solitary, bounded only by the overarching sky. More thoughts come crowding into the mind in presence of such a scene than are easy to express.'"

Such as are these English Dunes and Moors and Fens are the Landes, with which the sand dunes which have been reclaimed to man are associated, and of which they form a part. The special characteristic of them is the sand of which they are composed; the second characteristic of them is the superficial aspect which the hill-like accumulation of the sand gives to the contour of the country; a third characteristic is the constant onward movement of the sand landward, covering up valuable fertile land with sterile sand and stagnant waters; and the last, but not least remarkable characteristic is the forests which now wave over extensive areas thus recovered.

Of these the writer I have quoted,—I am unable to say whether M. Mangin or his translator,—for the latter states that he has made copious additions to the original work, with the view of rendering its scope more comprehensive and complete, and of adapting it specially to the requirements of the English reader—says:—"The works of Charlemagne, on which he employed his veterans to preserve imperilled cities, have been resumed, and with greater success, by a skilful agriculturist, M. Desbiey, of Bordeaux, and an able engineer, M. Bremontier, who have called in nature herself to assist man in his war against nature. Their system consists of sowing in the driest sand the seeds of the sea-pine, mixed with those of the broom *(genista scoparia)*, and the *psamma arenaria*. The spaces thus sown are then closely covered with branches to protect them from the action of the winds. These seeds germinate spontaneously. The brooms, which spring up rapidly, restrain the sand, while sheltering the young pines, and thenceforth the Dune ceases to move, because the wind can no longer unsettle its substance, and the grains are held together by the roots of the young plants. The work is always begun on the inland side, in order to protect the farmer and the peasant, and to withdraw the infant forest from the unwholesome influence of the ocean-winds. And, in order that the sown spaces

shall not themselves be buried under the sands blown up from the shore, a palisade of wicker-work is raised at a suitable distance, which, reinforced by young plants of sandwort *(psamma arenaria)*, check the moving sands for a sufficiently long time to favour the development of the seeds. Finally, the work is completed by the construction of a substantial wall, or rather an artificial cliff, which effectually prevents the further progress of the flood, or directs it seaward, to be arrested on its course by the barrier of the sand-hills. Unable to force a passage through these natural ramparts, they have excavated certain basins, more or less extensive, and more or less deep, which have formed inland seas, communicating with the Atlantic by one narrow issue.

"It is a noteworthy fact that, owing to the encroachment of the Dunes, these lakes have been constantly forced back upon the inland country. Fortunately, this menacing invasion of the sands has been checked by the great engineering works executed a few years ago; which, on the one hand, have fixed, and, as it were, solidified the Dunes, and, on the other, have provided for the regular outflow of the waters. The Landes have thus been opened to the persevering labours of the cultivator. The culture of the pine, and the manufacture of resinous substances, have largely extended, and the time, perhaps, is not far distant when these deserts will almost completely disappear; when these desolate and unproductive plains will pleasantly bloom, transformed into shadowy woods or verdurous meadows.

"To so fortunate a result nothing will more powerfully contribute than the embankment of the Dunes. These have been, in reality, the true scourge of this country; these were the moving desert, the constantly ascending sea, which had already engulfed forests, villages, even towns, under its billows of sand, and driven before it the terrified inhabitants of the coast."

The expressions employed in this intimation of what is expected remind a Scotsman of his Scottish paraphrase of the predictions of Isaiah—

"With joy and peace shall then be led
the glad converted lands;
The lofty mountains then shall sing,
the forests clap their hands.
Where briers grew 'midst barren wilds,
shall firs and myrtles spring;
And nature, through its utmost bounds,
eternal praises sing."

I have not seen these plantations, but I have in France had much conversation in regard to them with others of similar tastes who have resided in the midst of them. The accounts given to me were vague, but not more so than conversational statements in general are. They left on my mind the impression that on the sea margin there is a pretty broad beach, and some 100 yards or more from this—200 it may be, or 300—the trees have been planted in a belt following, to some extent, the line of the coast, and extending in breadth irregularly from half a mile to a mile, it may be, or more, beyond which the plantations are continued in strips of some breadth, crossing each other at right angles, and thus enclosing quadrangular patches or fields, which have been brought under cultivation. Upwards of 100,000 acres of land were reported to me as having been reclaimed, and to a considerable extent covered with trees.

CHAPTER III.

Legislation in Regard to the Planting of the Landes with Trees.

The planting of the Landes with trees was begun in 1789, under the direction of the Minister, M. Necker, (father of Madame de Stael).

On the *13th Messidor an IX* (2nd July, 1801), there was issued the following Arrêté, or Order, relative to the plantation with wood of the Dunes on the coast of Gascony.

"The Consuls of the Republic on the report of the Minister of the Interior, the Council of State having been heard, order :

"Art. 1. Measures shall be taken to continue to fix and to plant in wood the Dunes of the coasts of Gascony—beginning with those of La Teste—according to the plans presented by the citizen Bremontier, engineer, and the Prefect of the department of the Gironde.

"2. To this effect there shall be established a commission, composed of the chief engineer of the department, who shall preside, a forest administrator, and three members taken from the agricultural section of *La Société des sciences, arts et belles-lettres de Bourdeaux*, who shall be appointed by the Prefect on presentation by the society.

"The said commission shall direct and superintend the execution of the works, together with the employment of the funds which shall be appropriated thereto. The whole under the authority, and with the approval of, the Prefect." . . .

By another order, issued under date of the *3rd Jour complémentaire, an IX*, it was ordered :

"Art. I. The measures prescribed under Order of the *13th Messidor, an IX*, for the fixation and plantation of the Dunes on the coasts of Gascony shall, in what relates to wicker hurdles and other artificial works which they shall require, be discussed on the plans of the citizen Bremontier, Engineer-in-chief, and approved by the Prefect of the department of the Gironde ; and in what relates to sowings and plantations these must be arranged with the Administration of Forests.

"2. The expenses for hurdles and other artificial works shall be made from the funds of the department of the Interior, and those for the plantations and the salaries of forest agents from the funds appropriated to forests."

By decree of 12th July, 1808, it was declared: "Art. 22. There shall be established in the department of the Landes a commission for the plantation of the Dunes.

"This commission shall be organised in the same manner as that established at Bordeaux in execution of the decree of the *18th Messidor, an IX.*"

On the 14th December, 1810, the following decree was passed by Napoleon:

"Napoleon, &c.—On the report of our Minister of the Interior, our Council of State having been heard, we have decreed and do decree as follows:

"Art. 1. In the maritime departments there shall be taken measures for the sowing, the plantation, and the culture of vegetables known to be the most suitable for the fixation of Dunes.

"2. To this effect the Prefects of all the departments in which are Dunes shall cause to be prepared in their respective departments by the *Ingenieurs des Ponts et Chaussées*, a chart of the Dunes which are susceptible of being fixed by plantations appropriate to their nature; they shall cause to be distinguished on their charts the Dunes which belong to the domains, those which belong to communes, and those which are the property of private persons.

"3. Each Prefect shall draw out, or cause to be drawn out, in support of these charts, a memoir on the most advantageous manner of proceeding, according to localities, in the sowing and planting of the Dunes; they shall annex to this report a draft of regulations, which shall contain the measures of administration the most appropriate to his department, which can be usefully employed to effect the end desired.

"4. The charts, memoirs, and drafts of regulations, got up and drawn out in execution of the foregoing articles, shall be sent by the Prefects to our Minister of the Interior, who can, on the report of our Director-General *des Ponts et Chaussées*, order the plantation if the Dunes do not include any private property; and, in the contrary case, he shall make his report to us, to be by us decided in Council of State in the form adopted for regulations of public administration.

"5. In the cases in which the Dunes shall be the property of private persons, or of communes, the charts shall be published, and posted up in the forms prescribed by the law of 8th March, 1810; and if the said private persons or communes find themselves incapable of executing the works commanded, or refuse to do so, the public

administration shall be authorised to see to the plantation at their expense; they shall retain possession of the Dunes, and collect the proceeds of the fellings which may then be made, until complete recovery shall have been made of the expenses which have been incurred in the case, and of interest thereon; after this the Dunes shall return to the proprietors, under burden of maintaining satisfactorily the plantations thereon.

"6. In time coming no felling *de plants d'oyats*, of mat grass *épines maritimes*, pine trees, silver firs, larches, and other arenaceous plants, ministering to the conservation of the Dunes, shall be made without the special authorisation of the Director-General *des Ponts et Chaussées*, and on the advice of the Prefects.

"7. There shall be established Guards for the conservation of the plantations actually existing on the Dunes, or which shall be made there in time to come; their appointment, their number, their duties, their salary, their uniform, shall be regulated after the mode in use, for the guards of communal woods.

"Offences shall be prosecuted before the tribunal, and punished conformally to the provisions of the Penal Code.

"8. We do not design, by the present decree, to innovate aught on what is practised for the plantations which are being executed in the Dunes of the departments of the Landes, and of the department of the Gironde.

"9. Our Ministers of the Interior, and of Finances, are charged each in what concerns him, with the execution of this decree."

After the restoration there was decreed the following Ordinance:

"Ordinance of 5th February, 1817, relative to the fixation and the sowing of the Dunes on the departments of the Gironde and the Landes.

"Louis, &c.—On the reports of our Ministers, Secretaries of State in the departments of the Interior and of Finance, our Council of State being heard, we have ordained, and do ordain as follows:

"Art. 1. The works of fixation and of sowing the Dunes in the departments of the Gironde and of the Landes shall be resumed in 1817.

"These works shall, in regard to execution, be directed by our Director-General *des Ponts et Chaussées*, under the authority of our Minister of the Interior.

2. The necessary funds for this operation shall be charged in the budget *des Ponts et Chaussées*, the yearly credit must not exceed 90,000 francs for the two departments.

3. The works shall be executed, the expenditure made, and the accounts rendered, according to the mode adopted for the service *des Ponts et Chaussées.*

"4. In succession as the sowings reach an age which shall be afterwards determined, they shall cease to be entrusted to the Director *des Ponts et Chaussées;* but he shall transfer them to the General Administration of Forests.

"5. The General Administration of Forests shall furnish, free of charge, to the *Direction des Ponts et Chaussées,* the seeds, young trees, and boughs, yielded by the forests which they administer, which shall be necessary for the fixation and sowing of the Dunes.

"6. The *Ingenieurs des Ponts et Chaussées* are authorised to require assistance of the forest agents and guards in the tours of inspection which they shall have to make over the whole extent of the Dunes.

"7. It shall subsequently be decided what special measures shall be taken to prevent and to repress the offences which tend to destroy or to injure the works of sowing the Dunes.

"8. A regulation of our Director-General *des Ponts et Chaussées,* approved by our Minister, Secretary of State for the Interior, shall determine the advance of the works, their range and their surveillance. (This was done by a regulation dated 7th October, 1817.)

"9. The orders of 2nd July, and 20th September, 1807, are abrogated, together with all other provisions contrary to the present ordinance.

"10. Our Minister, Secretary of State for the Interior, is charged with the execution of the present ordinance."

On 29th April, 1862, was issued a decree, which places the superintendance of the Dunes within the duties of the Minister of Finance. * The provisions of this are as follows :

"Art. 2. The works of fixation, of maintenance, of conservation, and of exploitation of the Dunes in the maritime coast are placed within the range of duties of the Minister, Secretary of State of Finance, and they are entrusted to the Forest Administration.

"3. These provisions shall come into operation on 1st July, 1862.

"4. Our Ministers of State, of Finance, of Agriculture, of Commerce, and of Public Works, are charged each in what relates to his de-

* A law appears to have been issued in 1857, enjoining the draining and planting of all lands belonging to communities within the district of the Landes, but this I have not seen.

partment with the execution of the present decree, which shall be inserted in the *Bulletin des Lois.*

These enactments tell this much of the history of the work: that the views of M. Bremontier commended themselves to the execution of the Republic, and that he was entrusted with the execution of the work at the public expense, under legitimate restriction; that the work was ordered to be begun at the Dunes of La Teste in Gascony, in the first year of the present century, and seven years later they were begun on the Landes; that the work was carried out with if possible greater energy under Napoleon the 1st, and subsequently under Louis XIV; and that, carried out previously under the Minister of the Interior, they were in 1862 transferred to the control of the Minister of Finance, and entrusted to the Forest Administration.

CHAPTER IV.

Literature Relative to the Arrest and Cultivation of Drift-Sands in France.

The work of planting the Landes of Gascony, as has been stated, was begun in 1789.

In 1790 was published a *Memoire sur les Dunes, &c.*, by M. Bremontier, by whom the work was projected and begun under the direction of M. Necker. In this memoir M. Bremontier describes the formation of the sand-dunes, and of the measures which had been adopted to arrest the drifting of the sand.

In 1806 appeared a *Rapport sur les differents Memoirs de M. Bremontier*, by M. M. Laumont, *et autres.*

In 1827 was published *Historique de la creation d'une Richesse Millionaire, par la culture des Pins*, by M. Delamarre;

In 1831, a *Notice sur les travaux de la fixation des Dunes*, by M. Lefert, *Ingenieur des Ponts et des Chaussées*, in *Annales des Ponts et Chaussées*, 1831, *2nd Sémestre.*

In 1833, in *Annales des Ponts, &c., 1st Sémestre*, were reprinted the *Memoire* by Bremontier, and the *Rapport*, by Laumont and others, mentioned above.

1842, a *Notice sur le pin Maritime*, by M. Lorentz, appeared in *Annales forestiere.*

1847, a *Memoire sur les Dunes de Golf de Gascoyne, par M. Laval, Ingenieur en chef, Directeur des Ponts et Chaussées*, appeared in *Annales des Ponts, &c., 2nd Sémestre.*

This is spoken of as a very remarkable Memoir, which, though less extensive and comprehensive in subject than that of the distinguished Bremontier, fully and perfectly explains the formation of Dunes, and the latest and most approved methods employed to fix them.

In 1857 was published a second edition of *Mise en valeur des terres pauvres par le Pin Maritime*, by Amédée Boitel, *Inspecteur de l'agriculture.*

In 1862 appeared an interesting article entitled, *Le littoral de la France, by Elissée Reclus*, in the *Revue des Deux Mondes*, for December, 1862.

In 1864 was published *Traité de la Culture du Pin Maritime dans les Landes*, by Eloi Samanos, Paris. 8vo.

About this time, I presume, was published "The Desert World," by Arthur Mangin, from a translation of which, published by Nelson and Sons, I have quoted so largely; and Weld's "Tour through the Pyrenees," to which I am also so greatly indebted.

In 1870 an interesting report on the Landes of Gascony was made to the academy, by M. Faye.

These works I cite as bearing chiefly upon the planting of the Landes of Gascony and the Gironde.

The literature thus cited relates only to one aspect or department of a wider subject: The natural history of drift sands, and means of arresting and utilising them.

The literature on this subject is voluminous. It is chiefly in connection with sylviculture in Gascony that the students of the natural history of Dunes in France have published the results of their observations. It may be, and probably it was the case, that the planting of the Landes with trees called then for the study of the subject, and supplied, at the same time, the opportunity of careful observation. But much as we may owe to French writers on the subject, it is not to them alone that we are indebted for information on the subject; and none will be more ready than they, with the courtesy of their nation, and the honourable feeling of men of science, to admit that it is not to them or to their countrymen, but to others, we are indebted for information on many points surpassing in importance in their relation to physical geography what they have communicated, relating as this did chiefly, though not exclusively, to the cultivation of these Dunes when formed, and the practicability of doing so advantageously to all concerned.

While they were thus employed, in other nations the subject in other aspects of it was commanding and receiving attention. In 1832 appeared *Anleitung zum Auban der Sandflücken;* and in 1838 was published a work entitled *Over den Oorsprong en die Geschiedenis der Hollandsche Duinen*, by Hull. The latter relating to the origin of the Dunes, the former to the planting of them.

In 1841 appeared a paper, by G. Forchhammer, entitled *Geognostische Studien am Meeres Ufer*, in *Leonhard und Broun's Neues Jahrbuch für Mineralogie, Geognosie, Geologie, &c.* Jahrgang, 1841.

In 1846, was published *Die Inseln und Marschen der Herzogthümer Schleswig und Holstein.* Dresden and Leipsig. 3 vols. 8vo.

In 1850, *Der Dünenbau auf Ostsee, Küsten West-Preussens*, by G. C. A. Krause, 1850, appeared; and subsequently there was published.

In 1854, *Ansichten über die Bewaldung der Steppen des Europäischen Russlands*, by J. von den Brincken. Braunschwieg. 8vo.

In 1856 was published at Haarlem *De Boden von Nederlanden*, by W. C. H. Staring.

In 1861 was published at Copenhagen *Om Klit formationen og Klittens Behandling, og Bestyvelse*, by C. C. Andreson.

And in 1873 was published at Vienna *Der Europäische Flug sand und seine Kultur*, by Josef Wessely, in which is given a list of upwards of 100 books and papers on subjects pertaining to this department of forest science in Hungarian, Latin, and German, published in Hungary alone.

In our own language valuable information in regard to the natural history of sand, and of sand dunes, is given by the Honourable Mr G. P. Marsh in his volume on "The Earth as Modified by Human Action;" and by Professor R. C. Kedzie of the Agricultural College of the State of Michigan, in a lecture delivered at the College, in September, 1870; which will be printed in the appendix.

It does not come within the scope of my purpose in this volume to enter upon the consideration of the more comprehensive views of the subject thus opened up. The discussion of these is for the present postponed.

In accordance with what has been advanced in a previous chapter, is a narrative of the operations given in an article on pine trees, which appeared in the *Edinburgh Review* in October, 1864.

From this it appears the Landes, in Gascony in 1789, covered 300 square miles, ever shifting, and ever encroaching on the productive land beyond this sand. M. Bremontier, in the administration of forests, set himself to fix, and, if practicable, so to utilise this as to make it productive.

"In his report of proceedings, he compared this sandy tract to a billowy sea. It offered nothing to the eye but a monotonous repetition of white wavy hillocks perfectly destitute of vegetation. When violent storms of wind occurred, the surface of these downs was entirely changed—what were hills had become valleys, and valleys, hills. The sand on these occasions was often blown into the interior of the country, actually covering cultivated fields, villages, and even entire forests. This was done so gradually by a shower of particles as fine as the sand used for hour glasses that nothing was

destroyed. The sand gradually rose amongst the crops as if they were inundated with water; and the herbage and the tops of trees appeared quite green, and healthy even at the moment of their being submerged. On this moving and shifting sea, M. Bremontier sowed seeds of the common broom mixed with those of the pinaster, commencing on the side next the sea—or on that from which the wind generally prevailed, and sowing in narrow zones in directions at right angles to that of the wind. The first zone was protected by a line of hurdles, and after it was established, it protected the second, as the second did the third, and so on.

"To prevent the seed being blown away before it had germinated and become firmly rooted, he protected it by various ingenious modes, such as hurdles and thatching, and he had at last the gratification, after conquering many difficulties, of seeing his first zones firmly established. The rest was then comparatively easy; and by degrees the trees covered the whole of these sandy downs, not only providing the interior country with a barrier against the incursion of the sands, but turning the downs themselves from a desolate waste into a source of productive industry. Although the timber is of little value, the manufacture of tar, turpentine, and other resinous products furnishes sufficient occupation for the inhabitants, who are thinly scattered over large spaces. Among the efforts of man to control the elements and the powers of nature the conquests of the Landes from the desolation of the desert is entitled to a place beside the recovery of Holland from the empire of the sea.

"An agricultural genius, who, having studied agriculture, and particularly drainage, under scientific teachers, devised a system of reclaiming and husbandry, which has been very successful.

"Prosperity is rapidly following these improvements, and, what is better, malaria no longer poisons the reclaimed district. The peasantry enjoy better health, and M. Pierre firmly believes that the terrible *pellagri* will soon be unknown in the Landes."

CHAPTER V.

Culture of the Maritime Pine on the Landes of Gascony.

M. Boitel, in his volume entitled *Mise en valeur des Terres pauvres par le pin maritime*, supplies much of the information which is naturally desired in proceeding to enquire what steps should be taken in carrying out similar measures elsewhere.

The following is a resumé of the details of operations followed in Gascony, as reported by him. Having referred to the circumstance that these two distinct forms of sand-lands, the one situated more in the interior of the land, immobile, or at least settled, and ranked by geologists amongst the formations of the tertiary period; the other found in the neighbourhood of the sea, and belonging to the dune formations still going on, mobile, and affected by the winds; he describes, first, the formation of pineries, or plantations of pine on the fixed sands.

Operations are carried on generally thus on lands covered with heather, or heather brooms, and whins: If the land be capable of tillage they begin by enclosing it, so as to exclude cattle, which, but for this precaution, would over-run the plantation, and do great damage to the seedlings or plants. This is effected by the formation of what is locally called a *barradeau*, composed of an exterior ditch, the inner bank of which is furnished with a wall of earth covered with sods about a mètre, or 40 inches, in height. It is constructed entirely of earth dug in the formation of the ditch, and is almost vertical on the outside; on its inner side it is formed of the sand furnished by the same ditch, leaning against the wall to a height of 45 m.m., or 18 inches.

This done, advantage is taken of the weather to set fire to the bush, taking necessary precautions against the extension of this beyond the enclosure to the bush, or pineries adjacent. If the ditch be not deemed sufficient, a band of 1 or 2 mètres in breadth is cut with a scythe along the outside of the *barradeau*, and the bush and brushwood thus obtained is thrown into the interior of the enclosure.

When the growth of bush is strong and near a tile-work, it is often advantageous, instead of burning it on the ground, to sell it for use in the kiln.

Some careless proprietors sow the pine seed on the land amongst the bush, without any preparatory work. In such cases the seedlings push their way with difficulty, and the young pines remain long in a miserable and languishing state, if they do not altogether succumb in the struggle. In the district of Orleans a careful preparation of the soil is necessary, but in Gascony it is enough that the heath be mown or burned.

It is found advantageous to sow in September, but it may be sown on till May, and in favourable spots till the end of that month.

When the ground is free, five or six seeds are deposited in holes made with a small wooden trowel, 60 m.m., or 2 feet apart, and 10 or 12 inches deep. Where the ground is hard or covered with sod, the holes are dug with a pick-axe or a hoe. Brooms are sown at the same time to give shade and shelter to the seedlings, which are very sensitive, both to sunshine and to cold.

By Bremontier, first hurdles or wicker work, and afterwards trees were employed in his successful undertakings to arrest the drift-sands of the Landes, and the two appliances are used conjointly; while not a little is accomplished by the natural, or aided, spread of the indigenous vegetation, the different kinds of which, in accordance with the laws regulating the distribution of plants, grow well in their own domains.

"On the very margin of the sea," says Boitel, "that is at the limit reached by the waves on the slope of the coast directly opposed to all the marine influences, we admire the robust vegetation of the *calamagrostis arenaria*, (a species of small reed), called there *gourbet*; of the *triticum junceum*, (a species of Couch grass); and of the *Festuca sabulicola* (a species of Fescue grass). These are the three species of plants which, by their vivacious condition, their long, wide-stretching and resisting roots, their numerous and persistent leaves, and the length of their stipes, or stalks, contribute most powerfully to arrest the sands. Some other herbaceous plants also are feeble auxiliaries to them in doing so—such are the *convolvulus soldanella* (the sea convolvulus), the *arenaria peploides* (ovate leaved Honckenya), the *cakile maritima* (sea rocket), the *galum arenaria* (a species of lady's obedstraw), the *eryngium maritimum* (sea holly), and the *euphorbia paralis* (sea spurge).

"Leaving this little slope battered by the sea, and mounting the terrace which dominates the sea there for a breadth of from 400 to 500 mètres—ligneous vegetables are as yet unable to maintain them-

selves against the sea-breeze,—we find only a herbaceous vegetation, which comprehends the species which have been mentioned, and with them the following:—*Elychrysum stœchas* (a species of everlasting), *carex arenaria* (sand carex), *linaria serpyllifolia* (thyme-leaved toad flax), *thymus serpyllum* (wild thyme), *kœleria cristata* (crested kœleria), *aira canescens* (gray hair grass), *lotus corlatus* (nicurd's foot trefoil), *jasione montana* (common sheep's bit), *silene bicolor* (a species of campion, or catchfly), *alyssum arenarium* (sand alyssum), *hieraceum prostatum* (a species of hawkwood), *anthyllis vulneraria* (lady's fingers), *astragalus bayonensis* (a species of milk vetch), *medicago maritima* (seaside medick), *dianthus gallicus* (French pink), *ononis spinosa* (prickly rest-harrow), *sedum acre* (biting stonecrop), *diotis candidissiam* (white cotton weed), *thrincia hirta* (hairy thrincia), *crithmum maritimum* (sea camphire), *artemisia crinthmifolium* (camphire leaved wormwood)."

It is the zone which succeeds this last, extending from Bayonne to Cape Breton, which has, by the care of the Government, been devoted to the culture of the maritime pine.

In regard to outlying portions of the zone of plantations, he says:—"It is interesting to visit the maritime pines, which look like advanced posts, planted there to withstand the sea, and arrest the winds and the sand. Although they are under the shelter of an enormous screen of sand accumulated by the waves, they are all mutilated and deformed; no one has kept his head; they have the trunk laid against the ground, the branches are covered up with sand, and having assumed the appearance of young pine layers. The sea winds have levelled up the sand on them to a depth of 1.50 mèters, or 5 feet. The grains of sand driven by the tempest give to the leaves violent and multiplied strokes, which make them become yellow and dry.

"In proportion as the distance between them and the sea is increased, being numerous and varied, they give mutual support; they also increase in size, and resume by degrees their natural form.

"Beyond this zone of deformed and stunted pines we find at about a kilomètre, (two thirds of a mile) from the sea, beautiful pineries which furnish in abundance wood and resin. But it must always be born in mind that these pines never acquire the dimensions, the regularity, and the vertical growth of the pineries farther inland; the influence of the sea makes itself be felt over a radius of from 2 to 3 kilomètres (or two miles)."

Sometimes a spontaneous and vigorous vegetation fixes and consoli-

dates the sand on level spots which present little hold to the violence of the wind; but it is the maritime pine which plays the most important part in effecting this.

Two principal things have to be attended to by the forester to whom it is entrusted to sow the pines in these mobile lands. He must seek first to prevent the adjacent sand from invading and annihilating the sowing; and, second, to prevent the wind carrying away or otherwise modifying the surface of the ground sown: that is, in other words, he must fix down the adjoining sand, and protect the ground sown. The first must be done by plantation of Gourbet, *calamagrostis arenaria* (sand small reed), or by *clayonnages*, lines of wickerwork. We are indebted to Courreges, a careful observer, early lost to forest science, for the following notes preserved in the *Annales forestiere* for 1847, which relate to the employment of these wickerwork fences and the subsequent sowing of the seed.

"The *clayonnage* is the best means to employ to consolidate the drift-sands and prevent their displacement on parts exposed to the wind; and this is the first thing to do before proceeding to sow the seed.

"*Clayonnage* may be effected in three ways—first, with planks or beams; second, with stakes dressed with branches; third, with heather or other bushes.

"It is carried out in such a way as to receive at an angle of 45°, the winds coming from the north-west or from the south-west, which are the most violent winds, and those most to be feared for the sowings. It takes the form of a triangle of which the base is parallel to the shore, and the two sides form, with this base, an angle of 45°, the exact direction of the aforesaid winds."

The employment of planks and beams, in the structure of these, is almost abandoned. It is the most expensive of the three modes of *clayonnage*, and it does not appear to me that it would be of any use to describe it.

"The *Clayonnage* of stakes, is composed of poles, about 2 mètres (or nearly 7 feet) long, planted in lines some 20 inches apart. They are united by branches of heather, or other bushes placed as closely together as possible

"The *Clayonnage* of heather is formed of four parallel ranges of bundles of *Erica Scoparia* (small green-flowered heath), or of other bushes growing on the land, such as whins, brooms, &c. These bundles may be 9 or 10 inches in girth; they are planted—*quincunx*, fashion 6 inches apart—in lines 10 inches distant.

"The moving sand striking against this is stopped, and it gradually fills up all the intervals, and forms thus a slope with two sides. In proportion as the dune rises, care is taken to raise, from time to time, all the bundles of the four ranks until it is judged that the dune is sufficiently elevated to protect the sowings on the adjacent zone.

"The costs of the two are about the same; but the latter lasts longer, and is more easily maintained. Nevertheless, the former is perferred for points on which the wind acts with more force and violence."

Of the sowing, M. Courreges reports—

"They sow by hand broad cast 16 kilogrammes (about 35lbs.) of pine seed, and 7 kilogrammes (15½ lbs.) of broom seed to the acre, sowing the one after the other, because, being of different weights, they would be ill sown if they were mixed.

"They immediately cover up the surface sown with brushwood, composed of heather, whins, and other bushes, laid with the root to the wind, that they may be less easily raised by the action of the wind, and fixity is given to the covering by loading it with some shovelfuls of sand.

"Branches of the pine are little esteemed as a covering, because they very soon become despoiled of the leaves with which they are clothed.

"When the covering up of the ground is completed, it is well to cast over it 4 or 5 kilogrammes (9 or 10 lbs.) of pine seed, which falling between the branches, may come to replace seeds buried to too great a depth by the treading of the workmen.

"The broom and the maritime pine appear above the sand about the same time, but the broom developes more rapidly, and soon covers, with its shade, the young pines, the vegetation of which shows itself pretty promptly and pretty vigorously under the protecting shelter."

In the Landes they value the cork oak, and not without reason, because of its product, and it is often grown along with the maritime pine, under the shade and shelter of which it grows up erect, yielding its bark in good condition for sale, whereas otherwise it is apt to become bushy. It is sown in a similar way two years after the sowing of the pine.

In some cases, but not generally, pines produced by natural sowing on marshy land, are cut out with a sod of such size as to contain all the rootlets, and planted in holes dug for them of the same size, with

the same exposure, arranged in lines, and from 6 to 7 mètres, (20 to 24 feet) apart. This cannot be done with seedlings in sandy soil, as the soil would not cohere to the roots. When done quickly it often succeeds well; but with sundry disadvantages.

The trees yield resin as well as the others, but they do not grow so regularly as to yield equally useful wood.

By Boitel it is intimated that it is well that the young pines which grow in the vicinity of the sea should be numerous and closely grown, as they can then resist with greater efficacy the shock of the winds and storms, and, through the mutual support which they give, they are less likely to bend and break under the load of snow cast upon them in winter.

The expense being greatly increased by the covering of branches, to avoid this in many cases after the preliminary step of securing shelter by an artificial dune, raised by clayonnage, they wait till the sand is fixed by a spontaneous vegetation, or a plantation of *gourbet (calamagrostis arenaria)*, in spots a mètre, or 40 inches apart; and when this has been done the grain is sown or planted in accordance with the method adopted on old inland sands. This is found to do pretty well.

When none of the measures described are practicable, the seed is sown on the bare and mobile sand, and covered with branches of pine obtained from the thinnings and prunings of the nearest pineries.

In this case, the branches are disposed north and south; along-side of the first branch is laid a second; along-side of the second a third, and so on till the summit of the dune is reached. The branches are cut of equal length, somewhere between 3 mètres, or 3·50—or 10 and 12 feet.

The first line of branches being formed, a second is laid down, and a third, the one to the right, and the other to the left, in such a way that the branches intercross.

And to fix the whole, there is laid on the ends of the branches a pine pole of about 8 centimètres, 3 or 4 inches in circumference, which is fixed in the ground at the end with small hooks of wood.

If any part of the dune be firm, then this covering is dispensed with.

The expense of covering is great, but this need not be grudged, as the drift sands, once covered with pines, produce vigorous forests, which in a few years furnish wood and resins in abundance. And thus have these drift sands been arrested, and kept from carrying destruction to fields, and forests, and villages more remote, as may

be seen to have happened near the little lake of Léon, and at Vielle, a village of the Landes, where even the church disappeared under the sand borne thither by the wind.

In accordance with this account is the following given by M. Bagneris, *Inspecteur des Forêts, et Professeur a l'Ecole forestière de Nancy*, who visited the plantations in 1873 :—"In the month of January last," says he in a supplement to a volume published by him, entitled, *Manuel de Sylviculture*, "I made an excursion through the district of the Dunes, from Bayonne to Tremblade, accompanied by M. Nanquette, Director of the School of Forest Science, and my colleague, M. Broilliard. I can thus give an account of the means used for their fixation and *reboisement*. I also studied the treatment of the maritime pine as regards the collection of resinous products.

"On the low and sandy shores which skirt the sea between the mouths of the Adour and the Gironde, every tide bears along a very fine sand. At low water this sand is conveyed inland by the wind, making constant encroachments and it is always succeeded by more, whence result moving heaps, sometimes 70 mètres high (upwards of 230 feet), sloping gently on the side next the sea, and steep on that next the land. Sometimes these heaps take the form of continuous hills lying in straight lines with valleys between, sometimes they appear without any order. This depends on the coast line. The former arrangement is met with between the Adour and the Gironde, whilst at the Point de la Coubre the second form I found to prevail.

"These moving sand hills are called Dunes. It is ascertained that their progress landward is at the average rate of 4·30 m. a year (15 feet), and that the quantity of sand thus transported is about 75 cubic mètres to the running mètre of the length of the Dune. (Information given by M. Dutemps du Gric, *Conservateur* at Bourdeaux). The valleys there called *lettes* are of variable size, the bottom is flat and usually marshy where the Dunes are bare, or *dunes blanches* as they are called in that country.

"It may easily be imagined what an interest is taken in reclaiming and fixing these Dunes whose advance threatens to swallow up all, even menacing human habitations, which more than once it has been necessary to move inland from before them. In the first place the sand is temporarily arrested by means of *clagonnages* and stone, rooted plants, such as the *gourbet*, the spurge, the fesgue grass. The maritime pine follows to fix it and make it valuable. This last is admirably suited for such local conditions as there prevail. It grows naturally in mild climates, and its tap root is furnished with strong

lateral branches, which throw off throughout their length numerous secondary tap-roots. Along with these valuable properties it possesses the advantage of supplying valuable and abundant resinous products.

"The maritime pine has long been used in the Dunes. The forest of Teste must be several centuries old. But it will only thrive quite close to the sea. After the works carried on by Bremontier, which were begun in 1787, it was planted quite up to the brink of the beach. I shall state how this is done.

"Before putting in the seed a protecting barrier must be erected to prevent the sand from burying the seed and young trees. This barrier is nothing but an artificial Dune, called the *dune littorale;* it is formed by erecting a palisade parallel to the shore, at about 100 mètres from the high water mark. For this purpose planks are employed of about 1·60 mètres in length, 3 centimètres in thickness, and from 12 to 15 centimètres broad; a furrow, 40 centimètres deep, is dug in the sand, in which the planks are sunk to a depth of 20 centimètres, the lower ends being cut in a tapering form. In this way, when the furrow is filled up, the planks are buried to a depth of 60 centimètres, 1 mètre being above ground. They do not touch each other, a space of 2 centimètres being left between.

"The sand arrested by the palisade arranges itself in heaps sloping gently towards the sea; the interstices allow a certain quantity of sand to pass through, which increases the base, and consequently the solidity of the Dunes. When the palisades are almost covered, the planks are extracted by the help of a lever with claws, and the Dune goes on increasing. It should not increase too rapidly, because, if so, it might be destroyed by a wave.

"The better to secure its base behind the palisade a barrier is formed of stakes, of 2·50 mètres, between which flexible branches are interlaced. The stakes are driven in to a depth of 50 centimètres, and the clayonnages at first are only one mètre high; the height is increased as the Dune rises, and when it reaches the top of the stakes a new barrier is erected as the stakes cannot be removed as was done with the palisade.

"The whole is then consolidated by plantations of *gourbet*, which is arranged in tufts of from 5 to 6 stems, with 50 centimètres between each. The *gourbet* has this advantage, that as the sand increases in depth, the stalks rise, and produce roots which form a perfect network; 300 bundles of *gourbet* of 10 kilogrammes each, besides 6 kilogrammes of seed are required per hectare. The seed is sown

broad cast; the operation of planting, and the feet of the workmen assist in covering it.

"The palisade costs from 2·50 francs to 3 francs per mètre, it lasts five years when made of pine which has not been injected. Its keeping up and removal cost about 50 centimes a year. The barrier costs about 30 centimes per running mètre, and it should be renewed nearly every year.

"If there be any danger of the littoral Dune being injured by the wind, other palisades should be erected, at a certain angle with the first, on the sand which has been dislodged. At present there is a well kept up *dune littorale*, more than 200 kilomètres long, from the bar of the Adour to the mouth of the Gironde.

"When once a shelter from the wind is provided *reboisement* should be begun. This is done by scattering a mixture of the maritime pine, broom, whins, and *gourbet*. For example, in the operations carried on by the State, 10 kilogrammes of the seed of the maritime pine, 9 kilogrammes of broom, and 4 kilogrammes of *gourbet* seed are used per hectare. It is then covered by faggots of brushwood, broom, and whins. One man unties the bundles, two others spread them out, and a third places a spadeful of soil at every 50 centimètres to secure the covering which is absolutely necessary to prevent the seed being carried away, and especially to keep the sand in its place. For this purpose rushes are better than broom, because they furnish a better manure when decomposed.

"The seed should be sown, and the covering put on, simultaneously. At the close of each day additional earth should be laid on the last laid brushwood to protect it from the wind. Care should also be taken to arrange it equally and close to the ground, so as to leave no air holes, for in a single night the labour of several days may be lost.

"Pines, broom, and whins will grow together, and it is remarked that pines thrive best where the two last abound. When these are sparse much care must be taken in watching over the covering, as protection is necessary for four years. It should even be renewed, and this is one of the chief things to be done in maintaining the work.

"After some years the *reboisement* of the *dune littorale* may be proceeded with, by erecting a wide palisade nearer the sea, but whether this be done or not, the *dune littorale* must always be kept in good order, otherwise the works would be inevitably buried by the continual advance of the sand.

"Such is, in short, the kind of work to be done. It is often tedious, and, in certain circumstances, difficult. To consolidate and

plant with trees the Dune, will cost, at least, 500 francs per hectare. This outlay ceases, however, to appear exorbitant when we consider the protection which it provides. Almost the whole is laid out on the erection and keeping up of palisades, and chiefly in the transport from long distances, across moving sands of great depth, of the required planks and faggots of brushwood."

And it is stated by him that one effect of the *reboisement*—or, as that word is scarcely applicable though the word employed, the growth of the pineries—has the effect of drying up the stagnant water in the *lettes*, "either," says Boitel, "by the evaporation connected with vegetation, or more likely by the formation of mould, by which the moisture is absorbed and retained, or by some unknown operation."

Such artificial sowing as has been described may be necessary in taking in new ground, and it is practised elsewhere; but in the Landes natural reproduction is sufficient to maintain the pignadas.

"The pine," says Boitel," produces cones with impricated scales. These scales, compactly arranged, varnished, and of bone-like consistence, form a covering for the seed which may seem to be indestructible; but by an organisation which calls forth manifested admiration of the Providence, the scales which man could scarcely break by artificial means open as if by enchantment when they attain a certain temperature.

"The heat in dilating them, causing them to bend backward, separates them one from another, and in the new position thus taken they offer an easy exit to the winged seed which they had previously held imprisoned.

"Let it be borne in mind that the cones remain attached to the tree beyond the period of their maturity, that they are persistent and pendent on their peduncle, or stalk, and it will be seen that they are in a position admirably adapted for favouring the escape of the seed, and this, yielding to its weight, detaches itself freely from the opened out scale, and immediately by its wings it comes under the disseminating influence of the winds.

"The seeds thus sown germinate under the shade of the old trees, and form a young *repeuplement*, or new generation of trees, to take the place of the old when they shall pass away; and destined to be productive when the time shall come for the final and complete exploitation of the older trees reserved for this purpose.

"These natural sowings are, so to speak, the only means of produc-

ing the *repeuplement* of the pineries of Gascony required. The maritime pine finds in that land conditions so favourable to its development that it goes on reproducing itself indefinitely on the same ground, without any necessity for man to trouble himself about the sowing of fresh seeds. Often, in order that a sandy surface may cover itself spontaneously with young pines, it is enough to surround it with an enclosure, which shall keep out from the pasturage which it supplies cattle left without surveillance in the pineries."

An illustration of the importance of this occurs in one of the earlier works by Darwin. It is stated, if my memory serves me right, that on a piece of waste land or heath a common having been enclosed, forthwith, to the surprise of many, there began to grow up vigorously seedling pines, though pines had never been grown there before. And, on examination, it was found that all around, growing amongst the grass, were decapitated seedling trees, which had sprung up from self-sown seed, but been broken over by cattle grazing there; and apparently nothing more was required in order to the whole becoming a forest of pines than that this destructive operation should be prevented by a fence to exclude the cattle.

When the pineries become fairly established on the Dunes in Gascony, or on fixed sands more inland, which belong to the tertiary formation, they require, as the trees increase in size, to be subjected to periodical thinnings, and in some cases to moderate pruning judiciously executed.

"In thinning, attention is given to removing the worst of the trees, and to leave to the better trees the air, light, and space required for their perfect development. Pineries which are not thinned at the proper times suffer from this, as do crops overgrown by weeds from neglect of hoeing suffer from these injurious plants. The best sowings are those which are neither too sparse nor too dense; pines which have much space for growth develope more in breadth than in height; they present a dwarfed trunk, irregular and full of knots, and they are loaded with strong and vigorous crowns, conditions which are as unfavourable to the operation of tapping for resin as to the production of useful timber. If the plants remain too numerous and too close they famish one another, shoot up beyond what is desirable, and fall into an emaciated condition, in which they succumb to every injurious influence. The stems are slender; and the crowns, weak and few in number, fall off of themselves, leaving stumps, which disappear. But they recover them-

selves easily, and protect one another in the pineries which have been moderately thinned during the first twenty years of their growth. Beyond this general observation it is difficult to lay down precise rules in regard to the best means of executing thinnings. If germination have produced many more seedlings than was expected, it will do good to remove, by hand, a certain number of these at the age of 3 or 4 years, or as soon as they are seen to be injuring and starving one another; on the contrary, in a sowing which has come up badly, and which does not sufficiently cover the ground, the first thinning should be deferred till they have attained the age of 15 or 16 years. In ordinary circumstances pines require to be thinned when they have reached the age of 7 or 8 years. At this age the expense of the operation may be covered by the produce in faggots and charcoal wood. But in every case it is less the value of the produce than the future of the pines which should determine the time at which this first operation is to take place. That man would ill understand his own interests, and would imperil the continued existence of, and the revenue to be derived from, a young crop of seedling pine, who did not clear it of diseased and dying plants, on the ground that the expense of the work would not be entirely covered by the sale of the produce of the first thinning.

"The subsequent thinnings, *éclaircies*, as they are technically called in France, are determined by the kind of products which it is desired to obtain, regard being had to the nature of the soil and the state of the markets. In Sologne, for example, where the maritime pine does not grow well above 25 years, but where it furnishes faggots, for which there is a ready sale in Paris and Orleans, it is subjected to periodical moderate thinnings, carried out much as are the fellings of the coppice wood of deciduous trees. On a deep and firm sand where the maritime pine may form a timber forest fit for tapping for resin, and for the production of workable timber, the earlier thinnings ought to be somewhat more energetic, in order that they may favour more especially the trees destined to form the standing wood.

"In any case there is a risk of disappointment if there be a lack of prudence and moderation in the management of these successive thinnings. The maritime pine is a tree which, especially in youth, is very sensitive to cold winds, to hail, and to *coups de soleil;* it suffers greatly when, by excessive clearing or thinning, it is exposed suddenly and extensively to the air and the heat of which it has been deprived.

"Grown up pines of a slender trunk, terminating in a heavy and

bulky head, succumb easily to the action of strong winds, if there be removed, all at once, neighbouring trees which had served to shelter and protect them.

"The space which should be allotted to pines depends on their age, the vigour of their vegetation, and the nature of the products which it is desired they should yield.

"Delamarre, in Normandy, allows the following spaces round the trees :

1st *éclaircie*	at the age of	7	years,	...	0·33 mètres.
2nd „	„	8	„	...	·66 to 1 mètre.
3rd „	„	12	„	...	1·33 mètres.
4th „	„	16	„	...	1·66 „
5th „	„	20	„	...	2· „
6th „	„	24	„	...	2·33 „
7th „	„	28	„	...	2·66 „

A mètre is equal to nearly 40 inches.

"In Gascony pines destined for tapping for resin are allowed a space all round them.

At 20 years of age,	...	...	3 mètres.
„ 25 „	...	...	4 „
„ 40 „	...	...	5·50 „
„ 35 to 60 years of age,	...	...	7 „

"Timber woods of pines submitted to a definitive tapping contain about 200 trees to the hectare of nearly 2½ acres."

Élagage or pruning, in its application to the maritime pine, consists in removing one or more *couronnes* or tiers of branches, beginning with the lowest. Although the maritime pine appears to support amputation better than do most other resin yielding trees, "I have always observed," says Boitel, "that the removal of a certain number of *couronnes* was hurtful to the vigour and the health of the trees. The leaves play an important part among the nutritive organs; and if pruning do more harm to resinous trees than to broad leaved trees, which put forth new buds on the old wood, this must without doubt be attributable in a great measure to this—that the growing trees do not produce in place of the amputated branches young shoots, the leaves of which might discharge the functions of those which have disappeared by the operation of pruning. Pruning has, moveover, the inconvenience of leaving in the trunks running sores, which are healed with difficulty, and are the occasion of a pretty considerable loss of sap.

"It is remarked that the pines most loaded with branches and with leaves are those which give the greatest bulk of wood and the most abundant crops of resin. Notwithstanding this, pruning, objectionable in theory, becomes useful in certain peculiar cases. If there be seedlings with too much space around them, shooting out more in circumference than in height, and loading themselves with heavy and vigorous lateral *couronnes*, which absorb the greater part of the sap, then there is removed gradually the lower branches in order to concentrate the sap upon the stem, which is the part of the tree which it is of most importance to cause to increase in size and in length. As for sowings which are sufficiently stocked, instead of employing pruning to force the trees to shoot upwards, it is now advantageous to get the same result by moderating the thinning, and leaving on the ground as many trees as may be necessary to induce development in height, and one knows not how sufficiently to blame proprietors who, giving no attention to their seedlings for eight or ten years, all at once subject the reserved trees to a vigorous thinning, accompanied by an excessive *élagage* or pruning. This great mutilation, joined to a too immediate action of air and light, occasions a state of disease, from the injurious effects of which the pinery suffers throughout the whole period of its growth.

"*Elagage* is also proper on grown up pines, the lower *couronnes* of which, enfeebled by age, finally die and fall, leaving long stumps, which, in decaying, produce in the wood perforations which diminish much its value. This serious inconvenience is avoided by pruning away at a proper time languishing and dying boughs; and, in place of cutting them off close to the stem, leaving a stump 5 to 6 centimètres, or 2 and 2½ inches long.

"Such spikes, hardened by the action of resin which accumulates in them, embody themselves without difficulty in the trunks, and produce no other inconvenience than that of obstructing the tools in the working up of the wood. Spikes in parts of the trunk destined to be tapped for resin should not be above half-an-inch in length; otherwise, they arrest and blunt the hatchet of the *résinier* when he comes to make gashes where they are. The good of attending to this is experienced in the pineries of Gascony.

"At Belle-Isle M. Trochu prefers, on the contrary, pruning close to the trunk, and leaving no spike, executed in the beginning of winter, as being the method most favourable to the production of planks without knots and without holes.

"Both *Eclaircies*, or thinnings, and *Elagages*, or prunings, are delicate operations, which should only be entrusted to conscientious and skilled workmen. The woodman who is engaged on piece work works without other consideration than how he can increase the number of his faggots and of his carts of charcoal, and it is to be feared that in his precipitation he might sacrifice trees which in every respect deserve to be preserved."

CHAPTER VI.

Exploitation of the Pine Plantations of Gascony.

In the exploitation of forests there are two methods of procedure which have come down to us from times preceding these, in which the practical application of science to the management of forests has led to a more complicated, but more advantageous method, being adopted. In the one, single trees are cut down here and there, as required, leaving the others standing; in the other, extended areas are successively brought under the axe, and completely cleared. To the former method of procedure in France the designation *Jardinage* is given.

"Exploitation by Jardinage," says Boitel, "appears to me to be that most used by the inhabitants of the Landes. In the tapping for resin, and in the felling of trees, they give less attention to the *tout ensemble* of the pinery than to the special condition of the individual tree; on the same ground are seen very often numerous distinct generations of trees: some young, and good for removal in thinning the wood; others full grown, and regularly tapped; and others, in pine, more aged, and disappearing in proportion as they become less fit for yielding resin, and better adapted to yield workable timber or fire-wood. In these pineries it is by the natural spreading of the woods that the ground finds itself constantly clothed with trees, and it is the same in the pineries of Corsica and Spain."

But a more important feature of the pineries than the felling of the trees, is the collecting and manufacture of the resinous sap which they yield.

Full details of the various operations connected with this are given by M. Eloi Samanos, *Membre de la Société d'agriculture des Landes*, in his volume entitled "*Traité de la culture du Pin Maritime.*" The following more succinct account of these is given by M. Bagneris in his account of these plantations already cited.

"It seems to be well-known," writes M. Bagneris, "that *resinage* is not remunerative except where the maritime pine is indigenous, which is only in mild and warm climates. This tree is found in abundance on the ocean seaboard between the mouths of the Adour and the Gironde. To the north of the latter, between Royan and Rochefort,

it is less vigorous, produces less resin, and is of a smaller size; and the woods are not so thickly planted. Farther north, and especially in the basin of the Loire, where, as I think, foolishly it has been extensively introduced, it is not in its element. It does not reproduce itself naturally, it is short lived, its wood loses all its good qualities, and it is not possible to tap it with advantage.

"Resin never abounds unless the trees have plenty of room, are vigorous, and have thick foliage; it is thus a good plan to thin plantations at the age of from six to eight years. Till the age of twenty, the thinnings should be repeated every five or six years, so as to leave at that period no more than 600 or 700 trees per hectare. Those intended for felling should now be tapped. This is why 200 or 250 trees to be felled are now marked beforehand. When the plantation is thirty years old, only 250 or 300 should be left per hectare. This number is further reduced to 200 or even 150, which remain till nearly seventy or eighty years of age, when the pinery should be renewed, that is to say, if resinous products are not the chief object.

"This renewal may be effected either by means of the self-sown plants which have sprung up in later years, or by artificial planting. According to M. Eloi Samanos, this is usually done by seed in the Landes. As to the mode, he advises lines from 4 to 6 mètres distant from each other to be marked out, according as the trees are to be placed; this should be deeply trenched, either by the mattock or plough, for a breadth of 60 centimètres; 6 kilogrammes of seed should be allowed per hectare, which should be covered in by a slight harrowing.

"While the early thinnings are going on, before beginning the *gemmage* or tapping, the lower branches are lopped, so as to leave a bare trunk of at least 5 mètres high; this is to hinder the formation of dead branches which interfere with the flow of the resin. The incisions can be made more easily and regularly in the layers of wood covering these old wounds. Experience has proved the benefit of this, but, on lopping branches close to the stem, care should be taken not to enlarge the wound unnecessarily. It should always be remembered that a tree never has too many leaves, and therefore too many branches should never be lopped at once.

"It may easily be supposed that in thinning the young plantations and in lopping the lower branches, the soil is left without sufficient shelter. The sparse foliage of the pine adds to the evil. But there immediately appears a thick vegetation of grass, whins, heath, broom, thorns, &c.; this is a very valuable source of litter and manure. But

the forest does not profit thereby. Under the name of *soutrage*, this brushwood vegetation is collected and sold at 50 centimes per cart-load, containing about two cubic mètres. One hectare may produce from 5 to 12 cart-loads.

"It is evidently a loss to the forest that the vegetable mould should not be allowed to accumulate, but it clears paths for the *résiniers*, and diminishes the danger from the fires, which desolate the country in the summer months. This danger is so great that at certain distances large trenches are dug from 10 to 20 mètres broad, which are kept open for five years. In new plantations, and especially in the Dunes, these are made at every 1,000 mètres distant, so as to enclose squares containing 100 hectares.

"There are two methods of tapping, *le gemmage à vie* and *le gemmage à mort*. In both the *quarres* are opened thus: after having cut away part of the bark, it is pierced as far as the wood; at about ten *centimètres* from the foot of the tree an incision is made with a *habchat*, a kind of hatchet, the head of which is slightly hollowed out, and the handle is bent to the right. Once or twice a week the workman scarifies the wound, and increases its height by one centimètre. In the forests under the forest régime, the height of 4 mètres, 14 centimètres, should never be exceeded. The regulations also stipulate that the *quarres* should never exceed 12 centimètres in size, or one centimètre in depth.

"Trees to be *gemmé à vie*, should have only one incision made at a time, and it will tend to prolong the life of the tree that that should be only 8 centimètres in size. The same incision is kept open for five years, and is raised vertically, the first year 55 centimètres, the three following, 64, the fifth, 67 centimètres. When the five years are expired, another incision is made in the same way, and so on, till the time when the tree is *gemmé à mort*, previous to being felled. The *gemmage à vie* begins when the tree is one mètre in circumference. According to M. Lamarque it is good, especially at the beginning, to tap for four years and then to allow the tree to repose for one. The old incisions soon heal up, and after a certain time others may be opened above them, on the protuberances of bark which have formed, and which are called *ourles*.

"Here and there old pines may be found with a great number of *quarres*. It frequently happens that the old incisions are exposed owing to a want of adherence in the *ourles*. The latter shrink and causes swelling, so that the foot of the tree resembles a spindle.

One would think it was going to give way under the weight of its branches.

"In private woods the incisions are sometimes 4 or 5 mètres long, and 2 or 3 are opened at once on the old trees. This is a mistake, because, if more resin is obtained for the moment, the longevity of the tree is materially diminished.

"As has been said, *gemmage à mort* is practised on old trees which are to be felled, and upon those which are to be removed, so as to give more room to the others. With the latter, it is done so soon as they can bear a *quarre*, which is when they measure from 50 to 60 centimètres round, this they usually do at about twenty years of age. The *quarres* are opened as in the *gemmage à vie*, only they are enlarged more rapidly, and several are made on the tree at once. It usually takes three or four years to *gemmer à mort*, or to bleed them to death.

"When a *quarre* is opened or scarified the sap is seen in the form of drops on the exposed wood; some runs down the wound, the rest solidifies and forms a crust, this is the *Galipot*. In former times the *gemme* was allowed to run down to the foot of the tree, where it was collected in a little trough cut in a root or hollowed in the ground. A great deal was lost, especially during the first year, as much of it was absorbed by the sand. Now small earthen pots are hung on the tree, and are gradually raised so as to be on a level with the incision. To direct the *gemme* into the pot there is a little zinc spout slightly attached to the tree; the pot is kept in its place between this spout and a nail fixed below it on which it rests. To prevent any loss the pot may be covered by a piece of wood. The *résinier* or resin collector examines the pots when he scarifies the wound, and he empties them when full. The *Galipot* is scraped off once or twice in the course of the year.

"The use of pots and spouts is known as the system of M. Hughes. The outlay at first is greater, but the *gemme* is purer and in larger quantities, the difference being as four to three, so says M. Samanos. It is much employed in the Dunes, at Cape Breton, at Mimizan, at Biscarosse, at La Teste. It is less usual in Dax, and still less so at Mont de Marsan. The *gemmage* is there inferior, because, to prevent loss by absorption in the ground, the workmen lead the *gemme* from several *quarres* into the same trough. Now to do this they are obliged to cut spouts in the foot of the tree which pierce the wood almost completely round the tree, and this causes a rapid decay. *Gemmage*

is only performed between the 1st March and 15th October, but the bark may be begun to be removed from the 10th January. A pine *gemmé à vie* yields about three *litres*, or quarts of *gemme* when at its best, that is to say when its diameter is a least forty centimètres. It may also be alleged that taking into account the decreasing number of trees a hectare yields nearly a cask of 340 litres of resin yearly, whatever the age of the trees may be. It is more difficult to reckon the yield of the *gemmage à mort*. But it may be admitted that 200 to 250 trees of 20 centimètres in diameter yield about a *barrique* or hogshead yearly, and that for three years. At Biscarosse I have seen in a wood belonging to M. Marcellus, a pine 4 mètres in circumference, and with a bare trunk 11 mètres high, on which were 4 active *quarres*, which produced yearly from 7 to 8 litres of resin.

"The price of resin varies considerably. It is sometimes as low as 40 francs per *barrique* or hogshead, which is very little. During the American war it rose to 290 francs.

"At present (1873) raw resin brings 120 francs per *barrique* at Mont de Marsan, where it is manufactured. The *résinier* is paid at so much per *barrique*. His wages vary from 30 to 35 francs, which represents an average day's wage of from 4 to 5 francs.

"I have visited several manufactories at Mont de Marsan, in one of which essence of turpentine is distilled. It is done thus: the raw resin is put into a large reservoir; but as it always contains much foreign matter, according to the greater or less care taken in collecting it, earth, chips, bits of bark, leaves, &c. To separate these the raw resin is heated in coppers, taking care that the temperature does not rise so high as to disengage the essence. It is then filtered through rye straw and received in a trough in a state in which it is called *térébenthine*. From this trough it passes into an alembic by a valve which opens when necessary. During the distillation a thread of water is introduced by means of a pipe, and this becoming vaporised, it conveys the essence of turpentine along with it through the room, where both are received, in a liquid state, in a bucket, and separation is effected by decantation.

"What remains in the Alembic is made into resin, dry pitch, and yellow resin. It runs off through an opening below it to a pipe which leads it to a trough. The resin is obtained by filtering it through a very fine brass sieve placed over a box. Dry pitch is nothing but the residuum, which is at once run into moulds made in fine sand. It is formed into bricks of from 45 to 90 kilogrammes in weight. To

obtain yellow resin the residue is washed up warm with a tenth of water, and is also run into sand moulds.

"All these products are useful. The essence is used in making varnish, in painting, in polishing, and in cleaning furniture, &c. It is also used in medicine. Solid resin is used in making paper, soap, stearine candles, torches, and sealing wax, and it is also used in caulking vessels.

"The residue of the first filtration of the raw resin is burned in furnaces constructed for the purpose, the products being pitch and tar.

"One *barrique* of resin will produce 100 kilogrammes of essence of turpentine which at present is worth 125 francs. The other products cover the expense of manufacture, and yield a small profit. Dry pitch sells at 18 francs the 100 kilogrammes. The same weight of yellow resin fetches 20 francs. In another manufactory in the same town, by exposing the dry pitch to intense heat, a double decomposition is effected, and by different processes there are produced ethereal oils for making varnish; fixed oils, which are used for lamps, for greasing the iron-work of carriages, and for injecting wood, and in making printers' ink.

"All these products conjointly constitute the principal value of the maritime pine. But where there are means for removing it, the product of timber becomes important. There are different opinions as to the respective qualities of timber which has been *gemmé* or tapped, and not *gemmé*. In pines which have been *gemmé* the current of resin, owing to the evaporation of the essence, always leaves a good deal of concrete resin in the tissues, which increases their durability. The annual growth decreases in thickness; but data are awanting for making comparisons, as pines are rarely found which have not been tapped, and these have generally been left to serve as boundary lines between properties. They grow to a great size, but they are seldom felled till they begin to decay.

"One thing is certain, that the portion of the trunk which contains the incisions is too much broken up to be useful for the saw pit, but it furnishes very valuable and desirable vine poles; it is quite gorged with resin, which ensures their preservation. It will also make staves for casks to hold solid resinous matter. But the upper part of the tree is always free from breaks in the continuity. At Cape Breton I have seen planks seven feet long by seven inches broad, and five lines in thickness. In reducing these measurements to the metrical system it will be seen that 100 of

these planks are equivalent to 2 cubic mètres. They are sold at 70 francs per hundred.

"Railway sleepers can also be made. When injected they are worth 2 francs 10 cents each, delivered at the railway station. One may judge of the importance of this when we remember that the Southern French Railway and those of the north of Spain are laid on pine sleepers.

"To conclude, charcoal for forges is also made from the maritime pine. The cubic mètre of this charcoal weighs from 200 to 220 kilogrammes, and in the forest it brings from 18 to 20 francs."

In regard to the manufacture of charcoal, which occupies an important place in the exploitation of pine forests, M. Boitel reports: "Branches and very young trees are not saleable as fire-wood, but may be profitably converted into charcoal. In certain localities, where the roads are bad, and the centres of population are at a distance, the manufacture of charcoal is the only way of profitably employing wood, which, if in the form of *cotrets* or faggots, would cost a great deal for transport.

"Usually pieces of wood of from 4 to 5 centimètres in diameter are made into charcoal. Smaller ones are made into *bourrées*, small faggots; larger, into *cotrets* or *bois de service.*

"The first fellings, which are from six to ten years old, furnish wood for charcoal and *bourrées.* When the pines are older, charcoal is only made from the branches and upper parts of the stem.

"The best pieces for making charcoal are straight, not very thick, and sufficiently dry. They should not be more than from 0·75 mètres to 0·80 mètres in length. The crooked branches are cut into two or three pieces, the lateral twigs are cut off close, and the ends are round and smoothly cut. Twigs hinder the wood being properly arranged, and when the ends are ragged there is a good deal of charcoal lost. Green and dead wood are avoided. The first yields very little charcoal, the second only ashes, which may ignite the furnace after the workman believes it to have been completely extinguished—a great inconvenience, which spoils a great deal of charcoal and occasions conflagrations. The maritime pine is fit for the furnace six months after being felled.

"Spring and autumn are the best seasons for making charcoal. In summer it is dangerous to make it when there is no water. When possible, the charcoal maker should always have plenty of this at hand.

"In choosing a site for a furnace, the position of the timber to be used should be considered. A central position is best, so as to diminish the expense of land carriage. The ground is first levelled, and all heath and shrubs removed to prevent the chance of fire. The maritime pine is easily injured by the heat and smoke of a furnace, and it is best to place the kiln either outside the forest or else in the centre of a considerable clearing, as dead trees become a nursery of insects destructive to trees.

"Where old sites are conveniently situated, it is a good plan to make choice of these.

"When a new furnace is made the first bed should be laid on a layer of horizontal branches. This is called a *plancher*, a platform or floor.

"The size of the furnace varies according as the charcoal is for domestic or for other uses.

"For kitchen use, experts recommend that 15 or 18 *stères* or cubic mèters of wood should be burned at a time, and 30 or 35 when it is to be used in forges. Small furnaces occasion less waste, but sometimes they are apt to fail.

"The site of the furnace being prepared, a large post is placed vertically in the centre, the wood to be carbonised is placed round it after its being surrounded by twigs and dry wood which will ignite easily; the faggots are placed on end, but inclining gently; the first layer being made, a second, third, and fourth are added. In doing this the largest and greenest pieces are used for the lowest and most central part of the furnace, because there the fire burns most fiercely. The small dry pieces are placed on the outside and top of the mass. The faggots should be pressed closely together, and the interstices filled with twigs. If several kinds of wood are used at once, the hardest should be placed in the centre.

"The cone completed, the central post is withdrawn, and this leaves a chimney in the centre, the whole is then covered with leaves, twigs, earth, and moss, more or less mixed with sand. This layer of earth should be 5 or 6 centimètres thick. Fire is then set to the lower part of the chimney, which remains open a certain time so that the mass may be ignited. The chief fire is thus in the middle of the chimney, and the workman takes care to feed it with wood when a vacancy is produced. Whenever the mass is sufficiently ignited, the opening is stopped, the moment for doing this is regulated by the colour of the smoke, which, white at first, becomes blue and transparent when the flames acquire strength. The entrance and

exit of air must be regulated so that the heat may not be too great or too low. When too low, the charcoal is of inferior quality; when too high, there is great waste, and the yield of charcoal is small.

"The skill of a charcoal maker is now seen in ascertaining what progress the fire makes in the interior, in such a way that it can be moderated in some places and increased in others. It is by the smoke and cracks on the surface that this can be judged of. The fire is moderated by stopping the openings, or increased by making others.

"The bad effect of currents of wind is prevented by pallisades, or *bourrées*, arranged like a wall, or by a simple *clayonnage* of branches.

"The best constituted charcoal furnace is the one which, remaining uniform and homogeneous throughout the operation, sinks and breaks in regularly, allowing the smoke to escape in the same quantities from all the openings disposed round the furnace.

"The fire extends from above to below, and from the centre to the circumference. At the end of 36 hours, in furnaces of the usual size, the whole covering becomes incandéscent. This is the time of the '*grand feu.*' When this point is reached, M. Thomas says, that a good charcoal burner will make it blaze furiously, and then put it out dexterously. This, when done at the right time, produces a great deal of charcoal. But to prevent failure, the furnaces should be sheltered from currents of air, otherwise there is a chance of considerable loss.

"After the violent blaze, the charcoal making may be considered finished. The fire is moderated by degrees by making openings which allow the air to pass, and by replacing the warm dry earth of the covering by earth which is cold and damp. The fire is extinguished in five or six hours; but another day is required before the charcoal becomes cool and is fit to be carried away.

"To obtain a good yield of charcoal one must guard against raising the temperature too much at the beginning of the operation. The first part of the time is spent not in carbonising the wood, but in getting rid of the moisture. If the faggots are strongly heated before the water is dispelled, the latter being decomposed, two sorts of gas are created, which, combining with the charcoal, issue from the furnace in the form of carbonic acid, and carbonic oxide, and carburetted hydrogen. From thence results a real loss of carbon, which in this case is consumed in the same way as in our kitchen stoves. The water decomposed by the fire acts on the incandéscent charcoal with more force than would the atmospheric air.

"Well burned charcoal may be known by its hardness, and the sound it emits when struck. If nothing is lost in the furnace, 42 kilogrammes of charcoal are yielded by 100 kilogrammes of wood, but even in the most favourable cases this is never done. The most perfect operation does not yield more than 25 per 100. By the usual methods, only 15 or 20 per 100 are obtained.

"In Sologne the usual cord of charcoal is of the following dimensions :—

Height, ...	30 inches,	or 0·82 mètres.
Breadth, ...	30 „	or 0·82 „
Length, ...	16 feet,	or 5·33 „

Cubic measurement of a cord of charcoal, 3 *stéres*, 58, or 3·58 cub. „

"According to the success of the operation, a cord of charcoal produces from 4 or 4½, to 5 bags, containing 230 litres each.

The *stére* of dry pine weighs,	250 kilogrammes.
The cord of the same, ...	895 „
The hectolitre of dry pine charcoal,	19 „
The bag, ...	43 „

"The yield of 4 bags per cord is equivalent to 18 per 100 mètres weight. The yield of 5 bags per cord is equivalent to that of 24 per 100.

"Pine charcoal sells in the market at from 5 to 6 francs, oak charcoal from 10 to 12 francs. To give the charcoal burner an interest in the operation, his wages are regulated by the supply of charcoal he gets—45 cents per bag. Some proprietors who have confidence in their workmen, in place of paying by the bag, give them 2 francs for every cord of wood which is carbonised. Pine charcoal is lighter and of less value than that of the oak; the last weighs a quarter more, about 25 kilogrammes per hectolitre.

"The different kinds of charcoal are distinguished with difficulty. Merchants often fraudulently mix them.

"In Sologne, when pine charcoal is worth from 1·75 to 2·25 francs per bag, that of the oak is worth from 3 to 4 francs.

"Some years ago there was established at Sologne a manufactory where the pine was carbonised in air-tight vases. The volatile products were condensed, and produced by distillation tar and pyroligneous acid. Besides these articles, which are usually lost, the yield of charcoal was much greater. The death of the proprietor put an end to this interesting manufacture.

"There is in Sologne an encumbering kind of forest produce, which it is difficult to get rid of. I refer to the *bourrée*, a sort o

faggot bound by a single cord, exclusively composed of fragments from the saw-mill, or the clearings of the woods. In the Landes there are *bourrées* of a peculiar kind, formed of heath, broom, and whins. Whatever it is made of the *bourrée* is from 1 mètre to 1·33 mètres in length, and from 0·80 to 0·85 mètres in circumference. Sologne furnishes a great quantity of these *bourrées*, which are not needed for fuel, except when within reach of the great centres of population. They rarely pay the cost of being carried farther than 12 or 16 kilomètres.

"When they are not sold to the poorer classes for fire-wood it is necessary to get rid of them in such a way as to reimburse the proprietor for their collection. Rather than make an article which costs from 1 franc to 2 francs per hundred, and which it is difficult to sell, he would prefer to leave the twigs to rot on the spot so as to produce a sort of compost for the trees. In this case he should copy the Gascoyne farmer, who litters his cattle with the smaller twigs, which act as absorbents.

"In Sologne this is not the custom, and the *bourrées* are used in the manufacture of bricks, tiles, and lime. The manufacturers buy them at from 2 francs to 2 francs 50 cents the hundred, which leaves the proprietor a clear gain of 50 cents. The making of *bourrées* is a good employment for the idle season.

"Unfortunately, brick kilns are not able to use all the *bourrées* supplied by making *cotrets*, or faggots, of pine, and it would be impossible to sell all if they could not be converted into other articles made use of in various manufactories.

"For several years the *bourrées* have been burned in air-tight vases; *petite braise*, or charcoal cinders, is produced, and a more powdery sort of charcoal called charcoal dust. The experiment leaves nothing to be desired, for the *bourrées* are carbonised so perfectly that with care they may be withdrawn from the furnace in the same shape in which they were put in. Pine needles, leaves of heath, are perfectly carbonised, undergoing no physical change except in the colour, which changes from grey to black. Twigs of a certain size furnish *braise*, which is used in the same way as ordinary charcoal, but this article is of secondary importance beside the charcoal dust, which is the chief product. This is used in many manufactories. M. Popelin-Ducart uses it for the preparation of the cylindrical charcoal, known as *Charbon de Paris*.

"Such is the power of science. *Bourrées*, which would not repay the cost of transport to warm the inhabitants of Sologne, are,

after a chemical change, able to rival the ordinary charcoal in the furnaces and kitchens of Paris. This new article has to make its way against the prejudices of servants, but it may be hoped that at length it will be justly appreciated.

"Charcoal dust is used largely in the manufacture of artificial manures. It is known that carbon disinfects and solidifies the material. It is used for this purpose in several important towns. It is to be wished that this process of disinfection of drainage were more general. If it were so, what great services would be rendered to agriculture and the public health! In the first place, it opens a market for charcoal dust, which it is difficult to dispose of at present; and it preserves, for the benefit of agriculture, a great quantity of useful substances, which in towns are wasted, while at the sametime the air is vitiated and the public health endangered.

"Of two almost worthless articles, the *bourrées* of Sologne and the drainage of large towns, is thus composed a powerful manure, each hectolitre of which represents at least a hectolitre of wheat. When viewing the numerous advantages of such a manufacture, one is surprised that there has not been established long ago an interchange between Sologne and Paris of charcoal and disinfected and solidified sewage. What could be better than the carbonised heath being saturated in Paris with fertilising nature, and again restoring in Sologne fertility to the sterile soil which had produced it!

"If Sologne exchanged charcoal dust for disinfected drainage, the Landes which only require manure to be productive, would be cleared as if by enchantment, and would soon be covered with rich harvests.

"The improvement in the healthiness of the country which follows the progress of agriculture and this marvellous result, would both be attained by the use of fertilising substances which would otherwise be a powerful cause of disease.

"It would be a bold thing to say that such an end can be attained without difficulty. In the first place, there must first be invented a simple and easy way of making charcoal dust.

"When the dust is made, negotiations must be entered into with municipalities. Finally, to extend the sale, the resistance and prejudices of farmers must be subdued; but these men have been so often deceived by pretended artificial manures, that they stand aloof from any new substance."

There are given, by M. Boitel, the following details of the manufacture of charcoal dust:

"At the Imperial Castle of La Motte-Beuvron, Sologne, the carbonisation of *bourrées* is carried on in a brick oven placed in a central position in relation to the Forests or the Landes which are to yield the material, and special regard is had to the roads as it is desirable the oven should be near the best roads. Water also is required to extinguish the charcoal when drawn from the oven. It should therefore be of easy access.

"In such ovens or kilns the upper aperture of the oven, into which the *bourrées* are thrown, should be easily reached, and also the lower opening, from which the carbon is withdrawn. This double condition is attained by placing them where there are two surfaces with unequal levels. The upper opening on a level with the higher surface, while the lower is also on a level with the ground. This arrangement is to be seen in many lime kilns. The earliest kilns were not made in this way. The upper opening was above the ground by the whole height of the kiln. The workman could not throw in the *bourrées* at once, but was obliged to carry them up a scaffolding. This additional labour increased the expense.

"This inconvenience is prevented by erecting kilns of the kind described: In default of a suitable slope, the kiln may be placed on the ground, piling up earth to the half of its height and forming two inclined planes, one leading to the upper opening, the other leading down to the inferior one. Care should be taken to prevent rain from collecting in the oven.

"The *bourrées* are collected in isolated heaps in the neighbourhood of the oven. It is considered that these should not be massed together for fear of their taking fire; and that they should as much as possible be sheltered from rain. Wet *bourrées* are difficult to carbonise, and yield less powder, especially if they have been exposed to damp for any length of time.

"The workman throws in the *bourrées* either by hand or with a wooden fork. Thirty *bourrées* are enough to fill a kiln. It is lighted by the lateral opening; immediately it ignites this opening is carefully stopped with clay so as to exclude the air. The upper opening is left half open, from which issues a thick white smoke chiefly formed of vapour. So long as the smoke continues white, the workman throws no more *bourrées*, but whenever it loses a blueish tinge he hastens to feed it up, as this is a certain indication of an advanced degree of carbonisation.

"He continues to work all day without withdrawing the charcoal, and before leaving at night he puts in a fresh supply of *bourrées*.

At this time he covers up the upper opening entirely, but without hindering altogether the entrance of air and the issue of smoke: small apertures being indispensable. On the other hand, much air must not be admitted during the night, as then the moisture in the wood is entirely evaporated, and the charcoal powder may be converted into ashes.

"The carbonisation is completely finished when the workman returns to his kiln on the following morning. Although the kiln has not been hermetically sealed during the night there is but a slight loss of charcoal; the upper part only being affected by the air which is moveover surcharged with carbonic acid.

"The workman now hastens to withdraw the charcoal, and to extinguish it as completely as possible.

"By the lateral opening, he, with a little iron rake, draws out 2 hectolitres on to the inclined plane; he then shuts the opening instantly, and extinguishes the burning powder by watering it with a gardener's watering pan. He applies one litre of water to the hectolitre of powder; this quantity is not enough to extinguish it completely, but it is known that the powder is of better quality when subjected to *roulage*, instead of employing an operation to be immediately described, than it would be if more water were employed. The workman then takes a wooden rake and spreads the charcoal over an extent of about ten mètres. The charcoal is extinguished all the sooner by coming in contact with the cold earth, and an atmosphere composed of carbonic acid and steam. By this *roulage* the powder is exposed to the air in thin layers. The workman being careful to extinguish any sparks of fire.

"This operation is long and hurtful to the workman, he breathes a dry powder which incites him to drink, and injures his lungs. The workmen who drink abundantly of the bad water of the country often fall victims to fever.

"A workman spends three hours in extinguishing by *roulage* 20 hectolitres of powder.

"The kiln of the *Couscaudiere* consumes in a summer day, when supplied by two workmen, from 350 to 360 *bourrées*, and when supplied by only one workman, 260 or 280; 360 *bourrées* yield from 18 to 22 hectolitres of powder, which contain *braise* in the proportion of 6 to 15.

"This *braise* is separated from the powder by an iron sieve, the interstices being 2 centimètres across. The yield of braise varies according to the composition of the *bourrées*. The oak yields more than the birch, and the latter more than the maritime pine.

"As to the yield of powder, pine *bourrées* take the highest place. Careful carbonisation also affects the yield, a certain quantity being converted into ashes if the admission of air is not properly regulated.

"To prevent the necessity of continual superintendence, the workman is paid according to the yield. At La Motte-Beuvron he gets 15 centimes per hectolitre of powder.

"100 *bourrées* may be carbonised at the following cost:—

Price of 100 *bourrées*, ...	2 francs	0 cents.
Carriage, ...	1 „	0 „
Cost of manufacturing 6 hectolitres of powder, ...	0 „	90 „
Total,	3 francs	90 cents.

"From these 100 *bourrées* are obtained 6 hectolitres of powder, which is worth on the spot 50 cents the hectolitre, or 4 francs for 6 hectolitres. The net profit is 60 centimes per 100 *bourrées*. In this calculation I do not include the kiln, which costs very little, and lasts for a number of years. If the work be done by proprietors, it will be seen that their *bourrées* will bring them 2 francs 60 cents per 100.

"The expense of manufacture, at present 15 cents per hectolitre, would be very much diminished if several kilns were made at the same place. Whilst the *bourrées* are burning, the workman has a good deal of spare time. When he has the care of two kilns he can feed one while the *bourrées* are burning in the other. He can roll and extinguish the powder from one while attending to the fire in the other. But it must be kept in mind that a collection of kilns in one place increases the expense of carriage. If the roads be bad the kilns should be isolated, and built at equal distances. The expense of manufacture would be greater, but this would be largely compensated by the reduction in the expense of carriage. A kiln costs little, especially to proprietors who make their own brick and lime.

"The tools required by the charcoal burner are simple in the extreme.

"1st, a wooden fork to put the *bourrées* in the oven; 2nd, a long-handled iron rake to draw out the charcoal; 3rd, two gardener's zinc watering-pans; 4th, a wooden rake; 5th, a wire sieve; 6th, a half hectolitre measure; 7th, a large square shovel of sheet iron bent up at the side, each side measuring 0·38 mètres, with a wooden handle 0·80 mètres in length.

"Of all these tools the only one requiring improvement is the sieve, or riddle. It is of a rectangular shape, the longest side measures 1 mètre, the shorter 65 centimètres, 4 pieces of wood about 25 centimètres high form the frame. The net-work meshes are 2 centimètres in diameter, and are strengthened by transverse pieces of wood. It is fixed to a post by a hook and a double handle, which serves for putting in motion. It is with this sieve that the *braise* and the charcoal powder are separated.

"These two articles vary according to the composition of the *bourrées*."

In the Industrial Museum of Edinburgh, and it may be in other similar institutions situated elsewhere, there have been exhibited specimens of the products of the Landes, before and after having been reclaimed from the conditions of wastes of moving sand, and specimens of the implements employed in collecting the resinous products of the trees. They were presented by M. Leopold Javal, Deputy of the French Empire.

From a statement accompanying the specimens referred to, it appeared that the operations carried out on the ground where they were obtained were conducted by planting seedlings to the leeward of the older plantations, in intersecting narrow belts, and sheltering these with hurdles till they had taken root and begun to grow. This they soon did, and, thriving well in such situations, they very soon became strong enough to withstand the wind, and form live fences enclosing squares of considerable extent.

These enclosures were then sown with rape, mustard, and other rapid-growing crops, advantage being taken of wet weather to do this. When the seed produced by these had been collected, the remainder of the plant was ploughed in to produce vegetable mould, and the process was repeated until sufficient vegetable mould to support grain and other more valuable crops had been produced.

There were exhibited specimens of the sand, and of a bog iron ore found about three feet below the surface, known as *alios*, with specimens of the products of the land before cultivation. These consisted chiefly of the common brake *(Pteris aquilina)*; heather, or ling *(calluna vulgaris)*, which was used there, as elsewhere, for making brooms; the tree heath *(erica arborea)*, a heath indigenous in the south of Europe, and there found with stems measuring about an inch in diameter; and the furze, or whin *(ulex europœa)*.

Of products raised by cultivation there were exhibited white maize,

yellow maize, millet, little millet, buckwheat, rye, oats, wheat, and tobacco. There were exhibited sections of the cork tree *(quercus suber)*; of the black oak *(Q. nigra)*, a native of North America; of the holly leaved oak *(Q. gramuntia)*, which is indigenous in France; and of the cluster pine *(pinus pinaster)*, or Spardenny, of which the maritime pine *(P. maritima)* is conjectured to be a variety; there were exhibited specimens of this cut into railway sleepers, railway fencing, drain pipes, hop poles, shingle for roofing, and pavement for streets, stables, and footpaths; all of these had been infiltrated with blue vitriol (sulphate of copper) by the process of Bouchard, recommended as a prevention of rot and decay; and there were exhibited specimens of the following resinous products of the trees: Soft resin, collected in covered vessels; gallipot, or white resin, obtained by scraping the trees; barras, a coarse resin; sun turpentine, prepared by exposing soft resin to the action of the solar rays, and used in the manufacture of perfumery and of varnishes; bala turpentine, similar to the sun turpentine, but of inferior quality; Venice turpentine, which oozes through the joints of casks filled with soft resin; spirits of turpentine; rectified spirits of turpentine; resin, residuum of the distillation of rough turpentine or resin; tar, a product of the distillation of rough turpentine, and of the destructive distillation of wood; empyreumatic oil, obtained in the distillation of resin; lubricating grease, a mixture of resin and vegetable oils; and torches of resin used chiefly in Bretagne.

Of implements there were exhibited a common hatchet, a hatchet for making the broad shallow vertical grove in the bark and outer concentric circles of the trunk, to allow of the escape of the resinous sap, and for making the cut into which a zinc spout for collecting that sap is fixed: the edge was, an arc of a circle about $3\frac{1}{2}$ inches broad, and the head and handle formed an angle of about 135°; a course earthenware vessel in which the resinous sap is now generally collected: it would hold about $\frac{3}{4}$ pints, and was shaped like an earthenware milk pan, or coarse flowerpot of equal width and depth; a shovel for detaching gallipot and digging holes: it was like a hoe in shape, but solid; a second of the same of about 2 inches in breadth; a scraper for the same purpose, of the same breadth, but bent round like a crook to scrape downwards; a ladder made of the side of a young tree, with the edge cut into projecting angular steps.

The resins and the cereal products, exclusive of the fire-wood and timber, were said to suffice to cover the expense of management, and to supply a satisfactory return for the capital invested in the

enterprise, and of the reclaimed land brought under annual culture. And as regards the charcoal manufactured, it is remarked by M. Boitel:

"This would evidently be a source of possible wealth if the forests were easily accessible, but they are not so as yet at least in the Dunes, and will not be so until the newly planted trees arrive at a valuable age.

"Good roads are being made at present, and in future the maritime pine may be cultivated for the sake of its timber as well as for its resin.

"The culture of the maritime pine has conferred invaluable benefits. A considerable extent of low lying marshy land has been brought in, once a focus of pestilence which decimated the population. It has made it healthy and productive, and has introduced industry and comfort into districts which seemed doomed to misery. The maritime pine has also arrested the advance of the *Dunes* and prevented them from overwhelming houses and arable land. Its importance must increase. In the department of the Landes alone, the extent already planted is more than 500,000 hectares. In the Gironde there is almost as much, and very soon barren wastes and sandy dunes will be things of the past."

CHAPTER VII.

Sylviculture on the Landes of La Sologne.

Besides the Landes of Gascony and the Landes of the Gironde which are near the coast, we meet with Landes in inland situations in France, arid regions, supporting but a sparse population, being covered with heaths, and whins, and brooms, and other plants, which take possession of waste and uncultivated lands, and yield little nutriment for the support of man. Such are the Landes of La Sologne, of which mention has been made in connection with details given of the manufacture of charcoal; such also are the Landes of Le Brenne, and of Le Limousin—with solitudes broken only by the visits of poor shepherds tending or searching for their sheep, contrasting strangely with the animation and bustle prevailing in districts adjacent.

In these we meet with another phase of sand dunes and drifting sands, and of the culture of the maritime pine.

There, as in many other places elsewhere, the growth of the maritime pine is less luxuriant than it is in the district to which our attention has hitherto been given.

In the Landes of the Gironde the maritime pine propagates itself by natural reproduction by self-sown seeds. There, all conditions are peculiarly favourable to its growth. It is otherwise in the Department of Maine and in La Sologne.

In Sologne it is very rarely the case that a pinery is reproduced by self-sown seed. In the first place the trees never attain to great age, and they never furnish aught but a small quantity of seed. In the second place a *repeuplement*, when it does make its appearance, soon perishes under a dense covering of timber trees, which deprives it of air and light. In fine, young saplings, which may have withstood the injurious effects of too dense a shade, become oft-times the prey of flocks of sheep, which the people have the bad custom to lead into pineries, from which they should be strictly excluded.

Of the Landes of La Sologne and of La Brenne, it has been remarked that they are less known than are those of Gascony, because they do not lie upon the old great lines of communication.

They were once covered with a forest 1,200,000 acres in extent, but this having been cleared away, they have relapsed into what was their earlier condition, a barren sand waste, diversified by marsh land, and marshes in abundance.

In writing of the "Desert World," M. Mangin, or his translator into English, introducing his subject, says, "To those whose imaginations have been kindled by glowing pictures of the African Sahara and the Arabian wilderness, it will be, perhaps, a matter of surprise to learn that even fertile and civilised Europe includes within her boundaries regions which are scarcely less cheerless or desolate, though happily of far inferior extent.

"In France, so richly cultivated, so laborious, and so blessed by genial Nature as she is, there are, nevertheless, a few districts where her sons may wholly forget—nay, almost disbelieve in the existence of—her cities stirring with 'the hum of men,' her vineyards and her gardens, her grassy pastures, her prolific meadows, her well ordered highways, and those 'iron roads' which are the incessant channels of such restless energy, movement, and vigorous life."

And after describing mountain solitudes in the gigantic ranges of the Jura, the Vosges, and the Cevennes; the first an outlying spur of the great Alpine system, and situated on the border of Switzerland; the second separating the valley of the Rhine from that of the Moselle; the last separating the valley of the Loire from that of the basin of the Rhone, he goes on to reckon among the uncultivated regions of France, the marshes of the Bresse of Forez, and, with others, those of the Sologne.

The Landes or heaths of the Sologne appear as a desert surrounded by a magnificent girdle of cultivated land, fully developed in the fertile valleys of the Loire and the Cher. And, as is the case in Gascony, the heath is surrounded on all sides by valleys, vineyards, and gardens, in the highest state of cultivation. While in Corsica, another sandy desert, the orange, the olive, and the chesnut adorn spots surrounded with *maquis*, veritable heaths, with this, as the only difference between them and the heaths of the Sologne, that under that southern climate the whins and the meagre heaths are replaced by the arbutus, the myrtle, arborescent heaths, cistuses, and *lentisques*.

In all of the places mentioned, in Sologne, in Brenne, and in Gascony, it is not rare to see farms of from 1,500 to 2,000 hectares, in round numbers, 4,000 and 5,000 acres, with only from 150 to 200

hectares under cultivation; and in Corsica nine-tenths of the island are covered by the *maquis*, or heaths. In Gascony, to one who would urge the destruction of the heath, the agriculturist of Chalosse, or of Bearn would reply—*No heath, no maize;* exactly, as elsewhere, one would say—*No dung, no wheat.* And in that climate it is impossible to carry out a rational and profitable culture excepting on the bases of two hectares of heath for one under culture.

And there, by students of agricultural economy, it is deemed proper to seek the improvement of the poorer land by rearing trees upon it, instead of attempting to introduce at once the appliances of what is known as high farming. But even for woods the land here requires preparation, and the preparation which is found to be most appropriate is the culture of certain cereals, alternating with a growth of the maritime pine, without which it would be hazardous to attempt the growth of the Scots fir, the Corsican pine, and the Norway fir, and the oak, and the birch, all of which have been cultivated here with the best results.

But the land improver must wait many years before he can say whether the land will bear the other coniferae; and the oak, and other broad-leaved trees, it is alleged grow but slowly and require shelter. And even when the time has come to attempt the growth of such, it is not uncommon to grow a mixture of the maritime pine with the other coniferae, the oak, the birch, and the chesnut; as, should the others fail, it at least will grow; and if all succeed it is easy to sacrifice any one kind for the promotion of the growth of the others; and in any case it will give shelter to those which might suffer from frost, and it will yield marketable products, while the oak and the birch are still too young to be subjected to exploitation.

In Sologne we have a well-defined geological district, about 440,000 hectares, or above a million of acres in extent. The superficial strata have been designated by geologists specifically as the *Sands and Clays of the Sologne*, a formation reckoned among the upper layers of the middle range of the tertiary period.

It may be represented, says Boitel in his volume entitled "*Mise en valeur des Terres Pauvres par le Pin Maritime*," as a vast calcareous basin, filled by alternate deposits of sand and of clay. This basin, the wall of which crops out at a great many points along the circumference of La Sologne, presents naturally different depths at different localities.

In two borings, within yards of each other, at Savigny (Loiret)

we have in one a depth of 270 feet, and the other only 226½ feet; and a third at Vannes (Loiret), we have only 168 feet. And owing to accidental disturbances, and to the general inclination of the surface from east to west, one and another of the layers of which the deposit consists appear on the surface with a very great variation in breadth, giving rise to superficial ground of silicious sand, of clay, and of those elements associated in different proportions; and the sub-soil, which may be considered the true soil of the trees, presents modifications not less important in character and in depth.

All the layers which appear have, as a common character, that they are poor in lime and in fertilizing substances.

"In Sologne," says Boitel, "the lack of lime, the natural sterility of the country, the ignorance of those who exploit its products, the want of capital, the deficiency of labour, the undivided state of the property, whether held by communes or by individuals, and the striking ruin of some inexperienced innovators, are the main obstacles which have retarded the utilisation and improvement of the greater part of the uncultivated land."

Following out the natural division of the layers into sandy, clayey, and mixed lands, he says of these:

"*Sandy silicious soil* is formed of sand, more or less coarse, and more or less white; it is light and easily worked. Damp does not make it cohere, or change it into a thick oily paste. If it lies on an impermeable clay bed, without any fall, it becomes, in winter, saturated with water, and almost inaccessible to animals, who would sink into it up to their chests.

"But if there is a slight declivity it drains itself of its own accord, and is liable to become too dry in summer. Farmers sow it only with rye and buckwheat; turnips and red clover also succeed pretty well. In farms where no *boisement*, or planting with trees, has taken place for fifty years, it is often still arable. Old fashioned farmers prefer it, because it is easily worked, and because the effect of manure soon becomes apparent on the buckwheat and rye.

"Intelligent farmers, on the contrary, dislike it because of its rapid exhaustion, and because old manure can never be stored up in it, so as to yield a good return. Even supposing that lime could be had, it would be unsuitable for wheat and oats, it being poor in fertilizing substances, and because these cereals would suffer from drought before coming to maturity. Farmers subject these sandy soils to a fallow of lengthened duration; it then becomes covered with a whitish hair-grass *(aira canescens)*, with a species of woodruff

(asperula cynanchica), and sheep's bit *(jasione montana)*. After a repose of several years, a green compact moss follows, which is considered an indication that it will now bear one or two crops of barley without manure. Isolated plantations of chestnuts also succeed when the ground is deep and damp enough, also the oak and birch, but the maritime pine is most suitable. All the *sapinières*, or fir plantations, established in Sologne for the last twenty-five years have been planted in such ground.

"*Clay Soil.*—In Sologne sandy silicious soil covers the greatest extent; then comes clay, which is very different. When dry it contracts, cracks, and is difficult to work. When wet it is impermeable, and forms an oily tough paste or clay, suitable for the manufacture of tiles and bricks. These should not be made either in very dry or very wet weather, but only at times of a certain degree of dampness. Such soil is less easy to work than is sand; it requires stronger ploughs and more perfect implements. These considerations made old fashioned farmers exclude it from the list of arable soils. It is covered with oak woods and ponds, or is kept as pasture for sheep.

"The white oak easily becomes fit for exploitation, either as coppice or as timber trees. If the clay is pure and compact the *chêne rouvre*, or red oak, the variety chiefly grown in France, is to be preferred.

"Clay soil produces a stronger and richer vegetation. The smaller heaths being overtopped by the *erica scoparia*, vulgarly called *bremaille*, which obtains the height of 1·50 mètres. The dwarf whin is also found *(ulex nanus)*, some junipers and some grasses *(molinia cœrulea, agrostis vulgaris*, and *danthonia decumbens)*. Clay soils, although more difficult to work, are more profitable than are sandy ones; when drained, limed, and well manured, they are neither too hot nor too dry; the compost is not wasted, and it gives a good return.

"At the same time where argilo-silicious soils, which are better for cultivation, are to be had, clay soils should be wooded. The maritime pine will not thrive on it, the oak and pine should be chosen.

"*Soils Composed of Sand and Clay.*—This class comprehends all soils composed of mixtures of sand and clay, but such are rare in Sologne, and this is unfortunate for its agricultural future.

"If in place of elementary soils, pure sand and pure clay, the soil in Sologne were like the average ground in France, the farmer would be more frequently successful.

"The soils in Sologne are infinitely modified in composition; and then also modified through their connection with subterranean

springs. Before planting a firwood pinery it is necessary to ascertain if the soil and sub-soil are suitable to the maritime pine, as this tree pines in argilaceous, stiff, cold, and damp soils, and thrives in such as are deep, sandy, and well drained."

M. Boitel supplies also the following information on the comparative extents of wooded and arable ground in La Sologne: "About 1836 the forests covered an extent of about 38,730 hectares, which included those belonging to the state, to communes, and to private individuals. Since that time much sandy unproductive arable land has been planted with maritime pines, and I am not far from the truth in fixing the total extent so occupied in Sologne at 50,000 hectares. Forests thus cover one-eighth of the whole surface. The forest of Bruadan, lately uprooted, was famed for its size and for its beautiful oaks. The forests of Boulogne and Chambord take a high place. In the interior of Sologne may be mentioned those of Villette, Chaon, and many others lately planted with pines. The oldest forests are composed of white oak copse, growing under large timber of the same tree. These usually occupy a stiff clay. The pedunculated oak presents also a luxuriant appearance, reminding one of more fertile countries. The good success of deciduous trees proves that they have not so many requirements as herbaceous plants; for, while the latter cannot procure nourishment, the former, on the contrary, appear to derive from the sub-soil and the atmosphere everything necessary for their welfare.

"Such differences between these two classes of plants are often apparent. The marl so useful for crops seems positively hurtful to certain trees. The upper soil, exhausted by frequent cropping, appears equally favourable to the germination and the development of trees. The Solognese peasant says that sand is ripe for trees whenever barley refuses to grow.

"Trees with deciduous leaves, the oak in particular, are certainly the greatest improvement to the landscape; and when under the shade of these magnificent specimens scattered here and there on the edges of the farms, one questions whether the soil should be called sterile. Every domain, and, it may be said, every farm, has one part of woodland assigned to the proprietor. The oldest forests are coppices of oak and birch. The pedunculated or stalk-fruited oak occupies the argilo-silicious soil, whilst the oak with sessile acorns, is found on stiff clayey soil, where it succeeds as coppice better than any other tree. The new forests, planted within the last thirty years, are usually

formed of maritime pines. Isolated portions often look neglected, because the bad habit prevails of pasturing cattle in oak-coppice woods. There are even proprietors who tolerate this abuse in *les baux*. Plantations of maritime pines are better protected, but careless shepherds often allow their flocks to brouse on the young shoots.

"It may be remarked that *boisements*, or plantations of trees, are gradually encroaching on the arable ground. It is more than thirty years since this invasion began. The soil, naturally poor in lime and fertilizing elements, is rapidly exhausted by the prevailing bad farming. What can be done with such soil? Simply to sow three or four francs' worth of the seed of the maritime pine, and to wait for the growth of the young forest. Such an insignificant outlay preparing for a certain return being obtained from soil absolutely useless for agriculture.

"These improvements often take place on land otherwise unproductive, because it is the interest of the proprietors to do this. Subsequently a portion is cleared and made arable, and when exhausted by fifteen or twenty years' culture, it is again planted with wood. In this way in sandy cantons the farmer, or small land-holder, successively clearing and planting, becomes an important agent in re-converting the lands into forests."

In regard to the formation of pine woods in La Sologne, M. Boitel supplies the following information:

"*Preparation of the Ground.*—The extension of sylviculture, which would fall to be deprecated if it implied that the land planted with trees was land withdrawn from agriculture, comes to be desirable when it is carried out on land fit for the growth of trees alone, and which has become so only after a few years of temporary cultivation. In Sologne nothing is more difficult than to convert a Lande at once into a forest. The most experienced men carefully avoid attempting to do so; as when the soil of the Lande has been carefully prepared to receive the seed, it is at once covered by a vigorous vegetation of heath, broom, and gorse or whin, which never fail to choke the young trees. Immediate *boisement*, or plantation with trees, succeeds rarely, and only on very dry soils, where the heaths are stunted. Except in such rare conditions, it may be said the natural growth (heaths, broom, and gorse or whins) are stronger than the maritime pine, the oak, and the birch; when the seedlings come into collision, victory accrues to the indigenous growth of the soil. Sologne, in this respect, is very different from Gascony, where the maritime pine, by natural

sowing, invades the heaths when these are not under pasture; and further, on the Dunes of Gascony broom is employed successfully to shelter the infant pines!

"*Choice of Ground.*—Either arable ground or Landes may be planted. The latter cannot undergo the operation at once without being subjected to cultivation for several years.

"The arable land employed must of course be of the worst kind. Sandy, permeable, light soil is generally destined to *boisement*. Only special circumstances ever induce a proprietor to plant with trees all his property, whatever may be the nature of the soil; but planting may have to be carried on at the same time on pure sand, and on sand which is more or less mixed with clay.

"Before fixing on the trees to be used, the nature of the soil, and the requirements of convenience, must be consulted, and the selection should be of whatever will yield the highest and most permanent annual return.

"*Boisement* in Sologne is either permanent or temporary; permanent where it is in contemplation to farm a copse or a timber forest; temporary, when intended to prepare the soil for agriculture; and this may determine the choice of trees.

"For *temporary boisement*, trees which soon attain maturity should be chosen. The maritime pine, which in favourable circumstances attains the age of eighty years, rarely lasts more than twenty-five in Sologne. After this age the bark is covered with lichens, the growth is feeble, and it is at a loss if the *exploitation* be delayed. The ground which is cleared will then yield excellent crops without further expense than that of the working of the ground—thanks to the organic remains with which it is enriched by the trees grown upon it.

"In this way a rotation may be carried on according to the following formula:

Maritime pine,	...	...	20 to 25 years,
Idem,	...	...	... „ „
Rye and buckwheat,	...	...	so long as rye and buckwheat continue to thrive without the addition of manure.

"The soil when again exhausted, is again replenished with maritime pine, and so on continuously.

"In this rotation the pine plays the part of a doubly productive fallow, because, besides its commercial value, it restores to the soil the elements which are required in agriculture. We cannot too much admire the marvellous property of trees whereby they collect

and restore to the exhausted soil, the substances withdrawn from the air by their leaves [?] or from the subsoil by their roots. It supplies us with one of the main instances in agriculture in which time is of more value than money. With a great outlay in fertilizing a poor soil, the return may be uncertain or even ruinous to the cultivator. If, on the contrary, it be expended on *boisement*, or plantation of trees, where time is money, you attain your end by improving the fertility, and at the same time you produce the amelioration by a money return. It is only in the case of very good soil that time is here worth more than money.

"*Permanent or definite boisement.*—Temporary *boisement* makes the poor soil of Sologne produce every year, pines, rye, and buckwheat. Permanent *boisement* excludes agriculture, and the annual produce is exclusively that of the forest. This is obtained by mixing the oak, birch, and chesnut, with the pine, the coppice régime of which trees follows the exploitation of the last named tree. In Sologne both systems have both advocates and assailants. Unfortunately, discussion will not decide the point, and we do not as yet possess sufficient data to enable us to do so. But if we look at the subject from a philanthropic point of view, the first is to be preferred, because, instead of producing alone fire-wood and charcoal, it furnishes cereals, over and above, to a population at present obliged to have recourse to the importation of these from a distance.

"*Sowings of pines along with other trees.*—The maritime pine when grown by itself is treated as has been already detailed. When mixed with other trees there are no very important modifications of this. It acts as a shelter to coppice woods of oak, birch, and chestnut. These coppice woods continue growing while the pines remain, but they do not become really productive until after the exploitation of these. Instead of passing abruptly and completely from the culture of the pine wood, to that of the coppice woods of deciduous trees, there are sometimes left *baliveaux*, or standards, of maritime pines. In this way we have there a coppice of oak and birch under a timber forest of pines. This method is only to be adopted on soil which is very favourable to the pine.

"For mixed *boisements* it does not signify whether the soil is quite suited to the pine or not. The good of the trees which will permanently occupy the soil is more to be consulted. In any case, where the sand is shallow, Scots firs should be preferred.

"The trees to be mixed with pines should be, first, the red oak, on stiff clay; second, the white oak, on argilo-silicious soils; third, the

birch, in poor, damp, and deep sand; fourth, the chestnut, on rich, damp, and deep sand. The oak is very hardy; in poor soils it is the most productive.

"To conclude, it is not always easy to apply the rules laid down, on account of the varieties of soil; but to ensure success two kinds of deciduous trees should be associated with the pine—for example, the oak and birch.

"Fine coppice woods of chestnut are rare in Sologne, which seems to prove that the soil is unsuitable. Nevertheless, solitary specimens of chesnut trees of great beauty occur, but only in the neighbourhood of the farms, where they have had the benefit of manure and culture.

"The year in which the pines are sown may not always be a good year for acorns. In this case the latter may be pricked in later among the young pines.

"When the pines and acorns are sown at the same time, the acorns are first scattered in furrows, and when the ground is harrowed they are covered to the proper depth. The pine seed is then sown and covered by being slightly harrowed. Chestnuts are sown like acorns.

"Birch seed is not sown in Sologne; young plants, three years old, collected in the neighbourhood of the old trees, are preferred."

M. Boitel goes on to say: "Having pointed out the trees to be employed on *boisements*, we may now consider the respective merits of forests and agriculture as regards the general good.

"It is impossible to bring a poor soil at once into cultivation, and it may be considered as proved beyond a doubt that *reboisement* is the best way of improving land, and at the same time securing a speedy return.

"In Sologne, agriculture can only be profitably carried on in certain favoured spots where the soil, argilo-silicious or silicio-argillaceous, has been drained and manured; but it is evident that expensive improvements, in which the outlay exceeds the return, can only be carried out on a very small scale in Sologne. A farm of 100 to 150 hectares will only contain 20 or 30 hectares which have been treated in this way.

"It is impossible to establish the relative proportion which ought to exist between agriculture and *boisement*—local circumstances and the position of the proprietor differ so very much.

"The most experienced men devote to *boisement*, first, exhausted land which is usually sandy; second, Landes exceptionally poor.

"We have already said that these Landes cannot at once be

changed into forests; but when grubbed out, and subjected to the action of black cattle during two or three years, they yield crops, which repay the expense of grubbing, and which destroy the weeds.

"I have tried *boisements* on a large scale on the Imperial domains of Sologne. The following is the cost of sowing a hectare of exhausted land:

10 kilogrammes of maritime pine seed (winged) at 40 cents, ...	4 francs	0 cents.
1 kilogramme of Scotch fir seed (winged) at 3 francs, ...	3 „	0 „
150 litres of acorns at 3 cents,	4 „	50 „
50 litres of chestnuts at 5 cents,	2 „	50 „
Scattering the seed, ...	2 „	50 „
Total,	16 francs	50 cents.

"The expense of draining, levelling, enclosing, and weeding, varying according to locality, amounts, at the least, to 15 francs per hectare, so that the *reboisement* of a hectare will cost about 32 francs 50 cents, partly the seed, partly for hand labour. The expense of ploughing and harrowing must be added, but usually this is not great in these sandy soils. Land left in furrows only requires to be harrowed after the seed is scattered.

"This system of *boisement* is perfect and permanent, and free from risk.

"If the Scots fir does not germinate, which often happens, it should be replaced by the maritime pine, and *vice versa*. If resinous trees fail, the oak, birch, and chestnut will cover the ground sufficiently.

"Some *boisements* cost only 4 or 5 francs per hectare instead of 32 francs 50 cents, in which case the seed of the maritime pine is sown along with rye and buckwheat. The seed costs little, and the produce of the mixed culture pays for the ploughing and harrowing. This method has the drawback of risking all on a single tree, which may not succeed. On the other hand, it is to be supposed that the ground is not too far exhausted to be able to produce at least one other crop of rye and buckwheat; this is not usually the state of a field abandoned by farmers or small land holders.

"The young pineries, called here *sapinières*, are treated according to the method already described."

In the reclaiming of these Landes of La Sologne, we still find the

maritime pine playing an important part; but it is a subordinate *rôle*. It is employed here not as the one important culture, but as a means of preparing the soil for the culture of some of the poorer of the cereals, or as a manure to other trees, for the growth of which it has to make way, having secured its purpose, and in doing so exhausted its growth. In this respect, as in others, the Landes of Gascony and the Landes of La Sologne differ greatly; and thus a fuller study of these, more especially in particulars in which they differ from each other, may be desirable.

CHAPTER VIII.

Inland Sand-Wastes, and Sand-Wastes on the Coast.

The different conditions of the maritime pine grown on the Landes of Gascony, and of that tree grown on the Landes of La Sologne, indicate that there must be some great difference in the conditions of the sand-wastes themselves; and I deem it of much more importance to have this fact recognised by those who, without previous experience, may contemplate the reclaiming of sand-wastes by sylviculture, than to have the difference referred to precisely specified. All sand-wastes are not alike: there are sand-wastes; and there are sand-wastes; and there are trees which will grow luxuriantly upon one, which upon another will pine away and die.

Climate has to do with such results as well as soil. Sea air, and saline constituents of the soil, destructive to some trees, may be, like elements, life to others. The mobility of a drifting sand dune on the coast may be a condition of life to one tree, while the comparative fixity of an inland sand-waste may be essential to the growth of another. Something has been gained by the discovery that even the maritime pine, which has produced such wonderful results on the Landes of Gascony and of the Gironde, will not grow everywhere, even on sand-wastes in France. And the teaching of this is, that in every case in which it is sought thus to arrest and utilize sand-wastes, the culture must be determined by a special acquaintance with the case.

A previous study of the natural history of sand drifts and sand dunes might facilitate the acquisition of such an acquaintance with any one case as is referred to. But this comes not within the scope of this volume, which is limited to the single chapter of that subject indicated by its title. And it is the appearance presented by plantations on drift sands, and by lands adjacent to the pine plantations in Gascony alone, which have as yet been detailed. Points of similarity and of difference between these sands and the sands of La Sologne have only come before us incidentally.

With the fact before us, however, that there are differences in the conditions of sand-wastes, we may find it satisfactory to advance a little further in the study of these sand-wastes of France, less with a view of ascertaining the difference between the sand-wastes of the coast

and those of the interior of France, than with a view to becoming acquainted more extensively with the less superficial conditions of these sand-wastes than those previously detailed, whether common to all or peculiar to certain localities.

According to Herr Wessley, to whose work, entitled *Der Europäische Flugsand und Seine Kultur** I have already had occasion to refer, the "Landes" covering 270 German square miles (5,550 English square miles) of the province of Gascony, form the area of the basin of Bordeaux, a triangle bounded by the Atlantic, and formed by the land lying between the lower portion of the beds of the Garonne and of the Adour.

On the coast are the "Landes Sauvages," or coast dunes, covering an area of 19 German square miles, (nearly 400 English square miles), which, through drifting, have extended to a breadth which is unusual, and thereby has it frequently happened that the river courses far inland have been stopped up, and thus, through their waters penetrating into the Kehlen, or bared grooves, and hollows amongst the dunes, which cover more than half the land, have these waters been converted into lagoons and marshes.

The inland portion of the "Landes" forms a kind of plain from 250 to 300 feet above the level of the sea, an extensive sand heath covered with dunes, very much cut up, and of a composition so unfavourable to vegetation that in many parts it is throughout the year perfectly barren. It is only of late, as he says, that by extensive sylviculture, chiefly of the maritime pine, a considerable extent of forest has been produced, following mainly the water courses, and thereby a better produce from the land has been obtained.

The superficial covering of these heaths is composed principally of a very poor sand, devoid alike of clay and lime from 1·9 to 2·5 feet in depth, resting on an impenetrable under stratum, from 11 to 15 inches in thickness, which consists of sand cemented by calcareous and vegetable matter and is almost identical with the so-called German "*Ortstein.*" Under this stratum of *ortstein* again lies sand, and although in some places they have dug to a depth of 63 feet the lower extremity of this sand layer has not been reached.

In the summer season there is neither spring nor brook to be seen in these Landes. In the winter, however, being so near the sea, there is a plentiful fall of rain; and formerly, because of the little slope of

*Vienna: Fraesy and Freck. 1873.

the ground preventing a flowing off on any side, and the *ortstein* preventing its sinking into the ground, they were frequently flooded, and in this state they continued till the water was finally evaporated by the summer heat; and then things went to the other extreme, namely, a drought, because the vapour of the subterranean water could not pass through the stratum of *ortstein*. But here and there, where the *ortstein* was awanting, or had been broken through, places might be seen which were not so water drenched; on these grew wood very well, and showed that the barrenness was not attributable to the composition of the superficial layers.

The level of the subterranean water is about $3\frac{3}{4}$ feet below the surface. Water for drinking brought from that level is yellowish in colour, and harsh to the taste; it is only when brought from a depth of from 12 to 15 feet that the water begins to be drinkable.

In the wet localities described no oak can grow, for during the season of spring the whole heat is required for the evaporation of the water lodged there, and the oaks then expand their buds, and if these retain vitality at all it is only in the end of May, when the excess of moisture has disappeared, that they can burst forth, and then the delicate buds are exposed to the summer heat, and they succumb to the scorching sun of July.

The maritime pine has also its buds; and the period of its vegetation is also reduced by about two months by the stagnant waters; and by the ground ever passing through the alternation between excessive drought and excessive moisture, this tree also suffers in its growth, and on spots which do not become dry until the middle of summer it does not grow at all.

The importance of effects produced by the *ortstein*, of which mention has previously been made, under its local designation, *alios*, calls for some additional information being given in regard to it.

In writing of the Water Supply in South Africa, I have had occasion to refer to an impermeable layer in the sands of Namaqualand and other districts operating as does the *ortstein* here. There travellers, when driven to extremity for water, have found, on hollowing out a basin in the sand, that at a little depth they reached a layer of other matter; and after a time, more or less protracted, water collected in this basin, draining thither from and through the permeable sand, and retained there by the impermeable stratum, often not thicker than a penny, formed probably of clay, lime, and other matter washed down from the supernumbent sand. It is impermeable to water;

but great care has to be taken not to fracture it, as whenever this happens the water is lost, draining off to a lower depth.

In the Landes the stratum of impermeable matter spoken of by Herr Wessley, and there known as *alios*, contains iron in its composition; it has been spoken of as bog-iron-ore, and has been mentioned (ante p. 66) under this name among the products of the Landes exhibited by M. Leopold Javal.

The origin of this has been discussed by M. Faye, Director-General of the Administration of Forests in France, in a paper which appeared in the translation of the *Academie des sciences*, from a notice of which, in the *Athenæum*, it appears that M. Faye was engaged to level a portion of the Landes between the lakes on the coast and the basin of Arcachon, and made use of the opportunity to study the peculiarities of the soil. According to this notice: "At about three feet below the surface of the Landes, there lies everywhere an impermeable stratum called *alios*, a stony substance of a brown colour, variable in thickness, which is nowhere great, and covering an indefinite bed of sand, identical with that which lies above it. This invisible waterproof stratum has always had a great influence on the health of the inhabitants of the country. Retaining the products of vegetable decomposition from the upper soil, where there was scarcely any slope, the *alios* has for centuries fixed intermittent fever in and around the Landes; but reclamation has driven away the fever, and the *alios* seems now to have no other effect than that of forcing the roots of the marine pines to grow horizontally instead of vertically. The sand of the Landes is white, intermixed with a few black grains, containing peroxide of iron and oxide of manganesia. Washed, first by the water of the ocean, and afterwards by rain for centuries, it holds no soluble matter, and the *alios*, which is of a dark reddish brown colour, sufficiently compact to require a pick-axe to break it up, is a stratum of the same sand cemented together by some organic and slightly ferruginous substance. In the summer a hole made in the soil down to the *alios* fills gradually by lateral infiltration with yellowish water not fit for drinking; but if the *alios* is pierced an abundant supply of perfectly limpid water is obtained.

"The question is—How is this *alios* formed? It is evident that it was produced *in situ*, and the presence of the organic matter already mentioned leads to the supposition that the latter plays some part in the formation of this peculiar stratum.

"The *alios* is found everywhere in the Landes except in the marshes, on the banks of ponds, and in the downs, even when the latter,

protected by old forests, have never been swept by the winds for centuries. Soundings, and the knowledge of these exceptions, led M. Faye to the discovery of the mode in which the *alios* was formed. In winter and early spring the nearly level surface of the Landes is covered with rain-water, but during summer the level of this water descends by evaporation, to the depth of one or two mètres, a level which also corresponds with that of the ponds which border the chain of downs. If now we take into consideration the decomposition of vegetable matter which takes place in the water, and the deposit which must be produced at the lower level, it is easy to see why an agglomeration of sand and organic matter should take place at the depth already mentioned. This operation being repeated annually during many centuries, an increasing stratum of *alios* is naturally formed, which doubtless continues to grow at the present moment.

"It is not surprising then that no *alios* is to be found in the marshes which are always under water, nor in the downs which are not inundated, like the Landes, by a periodical sheet of water carried off regularly by evaporation, the rain as it falls being carried away by the slopes to the sea.

"But Whence come the traces of ferruginous matter which aid in the agglomeration of the *alios* and in giving it its red tint? It was shown long ago that the decomposition of roots and other vegetable matter brings the peroxide of iron contained in the soil into a state of inferior oxidation, and renders it liable to be attacked by the weak acids resulting from vegetable decay; more recently, M. Daubrée attributed the formation of the limonitic iron of the Swedish lakes to this chemical action, showing that iron thus rendered soluble over great areas is collected together by springs and rivulets, re-assumes its primitive oxidation, when the waters come in contact with the air, and is then deposited in the form of slime, and forms mineral strata of great richness. The same effect, but produced on the spot, would account for the small quantity of iron found in the *alios*. Vegetable decay has, in fact, produced in places the identical effect on the blackish portions of the sand of the Landes; where a fall in the level has caused a great accumulation of water there has been a concentration of iron, and in past times a certain number of furnaces worked up the iron, which is now exhausted.

"M. Faye, having explained the origin of *alios*, showed what effect an impermeable subsoil has on the salubrity of a district; the escape of the water is stopped, the subsoil becomes a centre of putrefaction and infection, and endemic malaria devastates the country. In the

Landes the evil has been remedied by cutting rather deep drains to carry off the water, and the roots of fern and other plants, which partly perish every year, have been replaced by those of the maritime pine. Thus the contamination of the air by the subsoil has been stopped, and with it the intermittent fevers which had given to the inhabitants a peculiar character of debility. M. Faye, after much observation, arrives at what he believes to be a principle, namely, that wherever an impermeable subsoil is found at a depth of two or three feet from the surface there will always be intermittent fever if the soil be contaminated by vegetable putridity, and fevers of a typhoidal character if animal decomposition be present. As to the remedy, it consists evidently either in draining, as adopted in the Landes, or in the removal of the vegetable or animal decomposition."

But of this stratum, Marsh says: "The *alios*, which, from its colour and consistence, was supposed to be a ferruginous formation, appears from recent observations to contain little iron, and to owe most of its peculiar properties to vegetable elements carried down into the soil by the percolation of rain-water. See *Revue des Eaux et Forêts*, for 1870, p. 301."

Whatever the source of the material and the process of its formation, the effects of its presence on the moisture of the sand-wastes and on vegetation there is great.

And from what has been advanced it appears that, in so far as moisture is concerned, dunes and sand plains are not always so devoid of water as they seem, and as the common expression Dry Sand would suggest.

Marsh, in connection with a remark made by himself, in which he says in regard to sand hillocks: "it is observed that from capillary attraction, evaporation from lower strata, and retention of rain-water, they are always moist a little below the surface," cites in a foot-note the following observations: "Dunes are always full of water, from the action of capillary attraction. Upon the summits one seldom needs to dig more than a foot to find the sand moist; and in the depressions fresh water is met with near the surface. FORCHHAMMER in Leonhard und Bronn for 1841, p. 5.

"On the other hand, Andresen, who has very carefully investigated this as well as all other dune phenomena, maintains that the humidity of the sand ridges cannot be derived from capillary attraction. He found by experiment that a heap of drift sand was not moistened to a greater height than eight and a half inches, after

standing with its base a whole night in water. He states the mean minimum of water contained by the sand of the dunes one foot below the surface, after a long drought, at two per cent.; the maximum, after a rainy month, at four per cent. At greater depths the quantity is larger. The hygroscopicity of the sand of the coast of Jutland he found to be 33 per cent., by measure, or 21·5 by weight. The annual precipitation on that coast is 27 inches, and, as the evaporation is about the same, he argues that rain-water does not penetrate far beneath the surface of the dunes, and concludes that their humidity can be explained only by the evaporation from below. *Om Klit formationen*, pp. 106–110.

"In the dunes of Algeria water is so abundant that wells are constantly dug in them at high points on their surface. They are sunk to the depth of three or four mètres only, and the water rises to the height of a mètre in them. LAURENT. *Memoire sur le Sahara*, pp. 11, 12, 13.

"The same writer observes (p. 14), that the hollows on the dunes are planted with palms which find moisture enough a little below the surface. It would hence seem that the proposal to fix the dunes which are supposed to threaten the Suez Canal, by planting the maritime pine and other trees upon them, is not altogether so absurd as it has been thought to be by some of those distinguished philanthropists of other nations who were distressed with fears that French capitalists would lose the money they had invested in that great undertaking.

"Ponds of water are often found in the depressions between the sand hills of the dune chains in the North American desert."

I have had occasion, in the volume on "Reboisement in France," to refer to certain experiments by Thurmann, in which cubes of different minerals, thoroughly dried, weighing each 100 grammes, were immersed in water for five minutes. He states that these gave the following results:—Liassic triassic, compact jurassic, liassic triassic, and oolithic limestones, granite, serpentine, basalt, dolerites, trachytes, &c., gave a mean absorption of 0·50 grammes of water. Similar minerals, including gneiss and compact marl schist somewhat disintegrated and changed, gave a mean absorption of 1·50 grammes; limestone still further decomposed, ferruginous oolites of Mt. Jura, liassic schists and grits from the Vosges, and eruptive rocks perceptibly changed, a mean absorption of 4 grammes; variegated grits, green coloured grits, calcareous chalks, gravelly clay, and sands, 7 grammes; and clays, Oxford marls, and kaolin, an absorption of from 10 to 30 grammes.

These observations, I there stated, Marchand considered indicative of the absorption of water being proportional to the state of sub-division of the material composing the rock; and this effect he resolved into their hygroscopicity and their capillarity—the former, the power of each molecule of the rock to retain around it a layer of moisture difficult to withdraw—the latter, the property possessed by many molecules of earth, to retain, in interstices by which they are separated, small globules of water.

From experiments and observations cited by Wessley, it appears that, of all the constituents of soil, sand manifests the least capability of absorbing water into its composition.

According to experiments by Schuebler, recorded in his *Agricultur-Chemie* (1830), a cubic mètre of the following substance contained of water the quantities stated:

	Kilogrammes.	In Weight.	In volume.
Quartz sand,	499	·25	·50
Pure grey clay,	875	·70	·87
Fine carbonate of lime,	808	·85	·81
Humid acid,	935	1·90	·94
Field earth,	745	·52	·75
Garden earth,	821	·89	·82

The size of the grains of sand has an influence, and the capability of absorbing moisture is increased with the fineness of the grains,—but much more by the admixture of clay and lime, and most of all by the addition of humid acid.

Pure quartz sand has no power of attracting moisture from the atmosphere, but it gains this power by the admixture of other substances; and the operation is promoted by the reduction of the size of the grains.

According to statements in Heyer's *Forstliche Bodenkunde*, founded on investigations by Schuebler, 5 grammes of the following substances spread out over 360 square centimètres, attracted from the air in 72 hours the affixed number of centi-grammes; and the proportions would have been the same whatever weight had been taken:

Pure quartz sand, ...	0·0
Pure grey clay, ...	24·5
Powdered carbonate of lime, ...	17·5
Humid acid, ...	60·
Field earth, ...	11·6
Garden earth, ...	26·

Again we find the effect intensified most of all by the admixture of humus, the operation of which is some three-fold that of clay and lime. Sand again is desiccated more rapidly than the other substances mentioned.

According to Schuebler, of 100 parts of absorbed water, reduced to the extent of 90 parts by exposure to a temperature of 15°, these substances yielded it up in the following times stated :

	In one hour.	In four hours.
Pure quartz sand,	4·07	88·4
Pure clay,	11·28	31·9
Powdered lime,	12·83	28·
Humid acid,	17·55	20·5
Field earth,	11·25	32·
Garden earth,	14·82	24·3

Further, it has been found by experiments by Kerner, that the finer the sand the longer does it retain moisture. And the observations cited show, that while this property is increased by an admixture of clay or lime, it is increased most of all by an admixture of humus.

The rainfall sinks quickly into porous sand. When rain falls slowly we find no puddles ; the rain is drawn off to feed subterranean waters, while, when it falls in deluges, it falls faster than it can sink, and, instead of flowing away over the surface, it flows away, carrying the sand with it, and often depositing this on ground at a lower level, to its utter devastation.

The coarser the sand the more quickly is it permeated by water. Kerner, in experiments, found the time to vary with this from two to twenty minutes.

With sand soil manured for agriculture it is otherwise. Grouven found, on experiments with turnip ground of diluvial sand, that in two hours 72 grammes of water dropped through an 8-inch layer, but he found the quantity in five other specimens to range from 15 to 62 grammes only ; while in five others it was doubled, ranging from 117 to 119 grammes ; while in four other specimens it was fourfold as much, ranging from 261 to 286.

The capillary attraction manifested by sand is remarkable. It not only operates quickly, but more quickly from below upward than water sinks from above downward when it falls in quantity.

According to Meister, quoted by Mayer in his *Agricultur-Chemie*, 1871, the ascent of water by capillary attraction in different substances was as follows :

	In ½ an hour.	In 2½ hours.	In 21½ hours.
Clayey soil,	34	115	200
Humus,	40	114	177
Garden ground,	29	98	161
Quartz sand,	44	97	117
Peaty soil,	27	57	114
Sandy soil,	45	66	90
Chalky soil,	6	54	70

In consequence of this, it is remarked by Wessley, the level of the subterranean water stands high in drift sand layers; and standing or running waters can with ease diffuse themselves sideways in sand layers.

The power of absorbing nutritive elements of vegetation is possessed by sand in a degree remarkably limited in comparison with the degree in which it is possessed by other soil. According to experiments by Grouven, 1,000 grammes of pressed northern diluvial sand, field soil absorbed:

Of potash, ...	24·1
Of ammonia, ...	18·6
Of phosphoric acid, ...	6·4

And the same quantity of loamy northern diluvial sand, field soil absorbed:

Of potash, ...	22·5
Of ammonia, ...	21·5
Of phosphoric acid, ...	21·5

While 22 samples of turnip field soil of different kinds absorbed:

Of potash, ...	from 66 to 137
Of ammonia, ...	from 35 to 134
Of phosphoric acid, ...	from 32 to 135

The power of absorbing ammonia from the atmosphere is, we see, possessed in the lowest degree by sand. Clay, mergel, and humus surpass all other soil in this. It is the same with the power of absorbing carbonic atmosphere from the air possessed by all of these substances in a wet state; this is least of all in sand, but it exists in the greatest degree in humus.

This power of the sand increases with the fineness of its particles; it may be observed to be proportional to the minute sub-division of the bodies operated on, and this property may be intensified in the sand by the admixture with it of the other substances mentioned.

The size of the grains of sand is very different in different places. The largest grains measure about a cubic millimètre, but the averages in different drift sands vary from 0·02 millimètres to 0·47.

The coarsest sands in Europe are those of the Northern Binnen Sands; those of the strand are disproportionately finer; in sand basins the particles are finest in the direction in which the diluvial waters found their exit; the sand is finer in dunes than in the blown out hollows between them; and in an extensive sand-waste the particles are finer at the extremity towards which the wind blows than at that by which it comes. The size of the particles has an influence, we have seen, not only on the degree to which it is liable to drift, but in the degree in which it may manifest many properties important to soil, amongst others, those of retaining moisture, one which is absolutely necessary to vegetation.

In accordance with what has been advanced is the testimony of Clavé:

"Composed of pure sand resting on an impermeable stratum called *alios*, the soil of the Landes was for centuries," writes Clavé,* "considered incapable of cultivation. Parched in summer, drowned in winter, it produced only ferns, rushes, and heath, and scarcely furnished pasturage for a few half starved flocks. To crown its miseries, this plain was continually threatened by the encroachments of the dunes, vast ridges of sand thrown up by the waves, for a distance of more than fifty leagues along the coast, and continually renewed, were driven inland by the west wind; and as they rolled over the plain they buried the soil and the hamlets, overcame all resistance, and advanced with fearful regularity. The whole province seemed doomed to certain destruction when Bremontier invented his method of fixing the dunes by plantations of the maritime pine."

The mobility of the sand is also most effectually arrested and prevented by moisture, and it is only renewed as desiccation takes place.

It may have been remarked that the sand on the sea-shore does not begin to drift so long as it is moist—that it only does so when it has become thoroughly dry; and that it ceases so soon as it is again moistened, whether by rain or by the rising tide. But what is mainly contemplated here is simply to show how it comes to pass

* *Etudes Forestieres*, p. 250. See also Reclus. *La Terre*, I., 105-106.

that vegetation can be extended over sand-wastes—even moisture existing there.

The *alios* is met with in the sands of the Landes of the Gironde, at a depth of about three feet below the surface. It is often about a foot in thickness, and underneath this is sand of unknown depth. Diggings have been made to a depth of upwards of 60 feet without reaching other material. In the winter season these Landes are covered with water which has no fall, and cannot sink through this layer; but in summer neither pool nor moisture is to be seen, the water having been evaporated, and the layer preventing an ascent of moisture from below. But, as has been intimated, there are spots where this stratum is awanting or has been broken, and on these grow bushes and trees, the ground neither being drenched in winter nor altogether devoid of moisture in summer.

Both in connection with notices of the drift sands of the Landes on the coast, and of the sand-wastes of La Sologne, mention has been made of peat lands and of marshes. These are found on sand-wastes in so many lands that the existence of them in such lands appears to be the rule, and the absence of them the exception. Suffice it here to state that a sand ridge may prevent escape of the waters by flow, and a stratum of *alios* or *ortstein*, or clay, or other impervious substance, may prevent escape by percolation.

From the treatise by Herr Wessley entitled, *Der Europäische Flugsand und seine Kultur* already cited, much information may be gathered in regard to the composition and condition of the sand-wastes of Europe.

In regard to the general appearance and composition of the drift sands of Europe, he says that in all places they consist in a vastly preponderating degree of fine somewhat rounded grains of quartz, with which only a small percentage of other materials are commingled.

The admixture consists primarily of felspar, which in old sand has for the most part experienced the disintegrating and decomposing effects of weathering, of lime, mostly fragments of shells; of mica; of magnetic, or Titanian ironstone; and finally, of different other minerals, hornblend, augite, hypersthen, basalt, and carbon.

The separate grains are more or less covered with a fine mould, on which depends next the fertility of the drift sands. For this depends in general on an admixture of products of the weathering just spoken of, or on those which the sand, the natural vegetation

and watering, or the culture, produces or attracts, of appropriate nutriment of plants.

The drift sand, strictly speaking, though variegated by a sprinkling of somewhat rare grains of darker coloured substances, is a mass of a light colour. Amongst the lightest coloured is the washed out sand of the north, which is of a greyish white. Amongst the darkest is the drift sand of the Bannat in Hungary, covered with a strong mould containing iron, which is of a yellowish light brown. In a wet state all drift sands are of a dark hue. So far as the surface is acquiring or has acquired a covering of vegetation of some years standing, it appears of a darker colour, varying with the kind of plant, with the richness of the vegetation in humus, and with the age of this, varying, for example, from a light grey brown to a black brown hue.

Many drift sands have also an admixture of a coarser form of sand, which on sea strand dunes is as large as pearls, and in inland situations goes indefinitely beyond this: round pieces, even to the size of blocks; concretions of lime of the most varied forms; shells of snails and of mussels; cemented clods; and the whole layer is hardened like stone. These larger sized materials are altogether absent in the wind-raised dunes. Such is the European drift sand in general. In individual cases, however, the character varies with the district, the origin and the thickness of the layer, and the transformations occasioned by geological changes, by vegetation, &c.

He reports the specific gravity of the different constituents, which, with the exception of the humus, which, on the authority of experiments by Schuebler, recorded in his *Agricultur-Chemie*, he gives as 1·370, ranges from 2·468 to 2·722; and he shows that the differences between 1·370 and 2·468 of specific gravity in sands, may be attributed to varying quantities of humus or products of vegetable decay in their composition.

As the result of numerous detailed experiments cited in an appendix embracing the composition of sands existing in numerous parts of Germany and Austria, he gives the specific gravity of the sands of North Germany as 2·5–2·9; average, 2·7; of the sands of Hungary, as 2·1–2·65; average, 2·5: attributing the greater weight of the former to the smaller quantity of lime, and the greater quantity of iron-ore, and mica in their composition. And, for comparison, he gives, on the authority of M. Schuebler, the specific gravity of arable land generally as 2·401, and of garden ground as 2·332; and on the authority of Hauer, that of the celebrated fields of Banat as 1·8–2·5; average, 1·18.

The coherence of sands of varied composition, as determined by Schuebler and others, give the following result:

"Taking perfectly dry, pure quartz sand as zero, a mixture of 4 per cent. of water gives it so much consistency that it may be pressed in the hand and cease to be driven of the wind; and this latter result follows an admixture of 4 per cent. of clay or 16 per cent. of lime, or 10 per cent. of humus. But what is thus gained by an admixture of humus, clay or lime, is lost by its being frozen in a moist state, on its being thawed, a peculiarity which it shares with all soils.

This, if it be so, may be attributable to the affinity of these substances for moisture, of which sand has little or none, leading to their absorbing all the free moisture, and leaving the quartzose sand dry and free to be blown away.

The commixture of lime and of clay with sand, so beneficial to the latter, has also this bad effect when it is considerable—that after heavy rains, followed by rapid desiccation, sometimes there is left on the surface of the sand a crust detrimental to vegetation.

Pure sand does not shrink in bulk in drying.

The following table, prepared in accordance with observations received by Schuebler, will make apparent the difference between pure sand and other earthy matters:

Pure sand loses in bulk in drying,	0 per cent.
Fine carbonate of lime, ...	5 „
Pure clay, ...	18·3 „
Humid acid, ...	20 „
Field earth, ...	12 „
Garden earth, ...	15 „

The latter numbers are indicative of there being contained in these bodies, as found on sandy regions, an admixture of humus or of clay.

Reference has been made to the effect of moisture in arresting and in preventing the drifting of sand. In view of the effect of heat in desiccating sand, and also in view of the effect of temperature on vegetation, the degree in which the properties of absorbing and of transmitting heat are possessed by sand deserve consideration.

The following results of experiments by Schuebler show the comparative capability of becoming heated possessed by sand. In the month of August, with an atmospheric temperature in the shade of from 22° to 25° R., 81° to 88° Fahr., the temperature of the following substances exposed to the bright sunshine were, according to the scale of Reaumeur:

	Wet.	Dry.
Quartz sand, pure yellowish grey in colour,	37·2	44·7
Pure clay, yellowish grey, ...	37·4	44·6
Humid acid, brownish black, ...	39·7	47·4
Field earth, grey, ...	36·9	44·2
Garden earth, blackish grey, ...	37·5	45·2

This table shows, first, that the power of becoming heated possessed by pure sand may be appreciably increased by an admixture of humus, apparently in consequence of the dark colour of this substance. The dry sand becomes heated some 21°, and the wet 13° R., 79° and 61° Fahr. above the temperature of the atmosphere; and while the sand is a bad conductor of heat, the heat does not penetrate to a great depth; much more is communicated by *conduction* and *radiation* to the superincumbent stratum of air. Kerner found on still warmer days than these on which Schuebler experimented that the temperature of drift-sand at Pesth half an inch below the superficial stratum was only 40° odds, and at three inches deep only 25° odds.

The faculty of retaining heat, or, in other words, the rapidity with which it is discharged, is something different from the capability of absorbing it, and the result of experiment by Schuebler, shows that representing the time required for cooling by lime as 100, the time required by other substances compared with it was as follows:

Quartz sand, ...	96
Pure clay, ...	67
Fine carbonate of lime, ...	61
Humid acid,...	49
Field earth,...	70
Garden earth, ...	65

After sunset the temperature of the superficial layers of the drift sand sinks very rapidly. Kerner saw on a broiling day in June, on the drift sand at Pesth, a thermometer sunk half an inch deep, which at sunshine showed 35½°, within three hours had sunk to 16°, from 112° to 68° Fahr.

The most superficial layer of the Hungarian drift sand shows the extraordinary great variation of temperature of from 40° to 45° R., 122° to 133° Fahr. But at the depth of only three inches the variation is only 25°, or 88° Fahr., and at four inches, at which depth the temperature in winter does not sink below the freezing point, the variation of temperature does not exceed 20°, 77° Fahr. But at the depth of three fathoms the annual variation does not

amount to ½° or 1° Fahr., and at that depth, at the elevation of about 300 feet above the sea level, the temperature is almost stationary at 10° R., or 54½° Fahr.

By directing our attention to the sand drifts of Sologne, and the sand drifts of the Landes of Gascony, we find we have had two different phases of sand drifts brought under our consideration; and as these two phases of these are to be met with again and again, sometimes in the same countries elsewhere, or the one and the other of them presenting themselves in lands which are far apart, the opportunity may be taken, before proceeding further, to consider at some length an important point in which they differ.

Of the two forms of sand deposit thus brought under consideration, "The one," to quote Marsh, "is that of dune or shifting hillock upon the coast; the other that of barren plain in the interior. The coast dunes are composed of sand washed up from the depths of the sea by the waves, and heaped in more or less rounded knolls and undulating ridges by the winds. The sand with which many plains are covered appears sometimes to have been deposited upon them while they were yet submerged beneath the sea; sometimes to have been drifted from the sea coast and scattered over them by wind currents; sometimes to have been washed upon them by running water. In these latter cases, the deposit, though in itself considerable, is comparatively narrow in extent, and irregular in distribution, while in the former it is often evenly spread over a very wide surface.

"In all great bodies of either sort, the silicious grains are the principal constituent, though, when not resulting from the disintegration of silicious rocks and still remaining in place, they are generally accompanied with a greater or less admixture of other mineral particles, and of animal and vegetable remains; and they are also usually somewhat changed in consistence by the ever varying conditions of temperature and moisture to which they have been exposed since their deposit. Unless the proportion of these latter ingredients is so large as to create a considerable adhesiveness in the mass, in which case it can no longer properly be called sand, it is infertile, and, if not charged with water, it is partially agglutinated by iron, lime, or other cement, or confined by alluvion resting upon it. It is much inclined to drift, whenever by any chance the vegetable network which in most cases thinly clothes it, and at the same time confines it, is broken.

"Human industry has not only fixed the flying dunes by plantations; but by mixing clay and other tenacious earths with the

superficial stratum of extensive sand plains, and by the application of fertilizing substances, it has made them abundantly productive of vegetable life."

From the information supplied, it appears that many inland expanses of sand drifts may be considered a resuscitation of sand deposits, which may have been quiescent for ages, fixed naturally by a similar mantle of vegetation to that by which man is artificially arresting and utilizing the same sand drifts or others situated elsewhere. With sand drifts on the sea coast it is to a great extent otherwise, though in some, even of these, there may be seen a resuscitation of sand previously partially fixed by vegetation in some of the earlier stages of the operation whereby extensive regions of sand dunes have for ages been confined.

Several of these are spoken of as belonging to the Tertiary formation, in explanation of which term it may be stated:

Geologists, in classifying the stratified layers of mineral substances covering the granite, consider that those of gneiss, and schist, and clay slates, were first deposited, and these are described by them as primary formations. Following these in order, and in many cases superimposed on them, are sandy slates, silurian limestones, and what is known as the old red sandstone. These are described by them as transition formations. They are followed by mountain limestone, coal beds, magnesian limestone, new red sandstone, shell limestone, lias limestone, oolite limestone, chalk beds, and green sand; and these are designated secondary formations. Above these are found blue and plastic clays, marls, and limestones, sands, and calcareous grits; and these are spoken of as tertiary formations; and above this, indicative of a later deposit, are diluvial clay deposited from seas or lakes, and boulders, alluvial clay deposited by rivers, and sand and gravel; and overlying these, the vegetable soil resulting from the decomposition of vegetable mould, and the admixture of the products with the superficial mineral layer.

From this it appears that the sand now spoken of is supposed to have been deposited in times long past.

An account has been given, cited from Boitel, of the way in which, on the Landes of La Sologne, heaths on these old sands are planted with the maritime pine. In other inland situations we find these sands of the tertiary formation throughout extensive districts covered with forests of trees of other kinds, varying according to conditions and circumstances—such, for example, is the famous forest

of Fontainbleau, visited constantly by many of the visitors to Paris.

The forest of Fontainbleau covers an area of about 64 square miles. But it by no means corresponds with the idea generally entertained of a forest; it is anything but an old, shadowy, leafy, and almost impervious forest. To quote the description given of it by Mangin: "Despite its enormous trees, its rudely broken surface, its stags and roebucks, reserved for imperial sport; despite its few adders and problematical vipers, it is now little better than a rendezvous for amateur artists and listless idlers. Its well-kept avenues resound with rapid wheels, and you can scarcely stir a step without finding the associations of the place interrupted by the stalls of vendors of cakes, or the apparatus of itinerant gamblers—a profanation to be regretted, for the forest exhibits many landscapes of surpassing interest in the rocks of Franchart, the glens of Apremont, and, above all, that Sahara in miniature, the sands of Arbonne."

An article by M. Clavé in the *Revue des Deux Mondes* for May, 1863, on *La Forêt de Fontainbleau*, contains much valuable and interesting information in regard to this forest, and in regard to matters connected with it. "Oaks," says he, "mingled with birches in due proportion, may arrive at the age of five or six hundred years in full vigour, and they attain dimensions which I have never seen surpassed; when, however, they are wholly unmixed with other trees they begin to decay, and die at the top at the age of forty or fifty years, like men old before their time, weary of the world, and longing to quit it. This has been observed in most of the oak plantations of which I have spoken, and they have not been able to attain to full growth. When the vegetation was perceived to languish, they were cut, in the hope that the new shoots would succeed better than the original trees; and, in fact, they appeared to be recovering for the first few years. But the shoots were attacked with the same decay, and the operation had to be renewed at shorter and shorter intervals, until at last it was found necessary to treat as coppice-woods plantations originally designed for the full grown system. Nor was this all: the soil, periodically bared by those cuttings, became impoverished, and less suited to the growth of the oak. . . . It was then proposed to introduce the pine, and plant with it the vacancies and glades. . . . By this means the forest was saved from the ruin which threatened it, and now more than 10,000 acres of pines from fifteen to thirty years old are disseminated at various points, sometimes intermixed with broad-leaved trees, sometimes forming groves by themselves."

The soil of the forest of Fontainbleau is composed almost entirely of sand, interspersed with ledges of rock. The sand forms ninety-eight per cent. of the earth, and it is almost without water; it would be a drifting desert but for the trees growing and artifically propagated upon it.

In reference to such superficial sand formations, the following remarks are made by Wessley:

"It is scarcely to be supposed that all inland sand drifts have been lying exposed, and drifted about since anti-diluvian times. On the contrary, we find almost everywhere that diluvial sands, by a slow but ever advancing natural process, become gradually covered with herbage, and ultimately with bush or forest, whereby they become so fixed as to be unmoved by the wind. And this process goes on all the more rapidly if man do not disturb it—if he do not promote it.

"And what has been effected thus in pre-historic times, is both denser and more during that what has been effected in later years: as the soil of that is richer in humus than is any planted by the hand of man. And these oldest plant-bearing sands may be described, as we sometimes describe nations, as the aboriginal vegetation of the ground on which they are found." Such seems to be the case with the oak forest of Fontainbleau.

Other forests growing indigenously on sands of the tertiary formation might be cited; but it is considered that one case of such is sufficient to show that forests may be produced and grow permanently on sands, and to give some idea of appearances produced by these.

What was at one time in the world's history, the natural state of these lands of La Sologne, a country more or less covered with forest trees, is what sylviculture is seeking to reproduce there, and to produce artificially on the Landes of Gascony and elsewhere; and what has been effected by self-sown seed may be effected again by artificial culture, if the natural history of the trees employed be known.

We have seen the good effect with which this has been done in Belgium, and on the Landes of the Gironde and of Gascony; and with what similar effect it has been done on the Landes of La Sologne. By Jules Clavé, a student of forest science of world-wide fame, it is stated in a paper in the *Revue des Deux Mondes* for March, 1866, that the district of Sologne, flat and marshy as it is, was salubrious until its forests were felled. It then became pestilential, but of late years its healthfulness has been restored with its forest plantations.

CHAPTER IX.

Natural History and General Culture of the Scotch Fir in France.

Of the trees spoken of as cultivated on the sand-wastes of France, the principal are the maritime pine (*pinus maritima*), and the Scotch fir (*pinus sylvestris*), the former on the new dunes and drift sands of the coast, the latter on the more consolidated old sand-wastes of the tertiary formation in the interior of the country. Besides these have been mentioned several varieties of the oak, the birch, and the chestnut, as grown on spots of greater or lesser extent within these sand-wastes; and in other countries a much greater variety of trees are raised upon sands and sandy soil. But it is the pine plantations alone of which this volume treats.

Mention has also been made of the modern system of forest management having been adopted in France; the *Fachwerke Methode* of Hartig and Cotta, known in France as *La méthode des compartiments*, whereby are secured in combination a sustained production of material by the forest, a progressive improvement of the state of the forest, and a natural reproduction of it from self-sown seed. As this method of forest management, now practised generally on the continent of Europe, and of late years introduced into the management of forests in the Indian Empire, differs entirely from the system known as *Jardinage*, followed in some of our colonies, and in what are called policies in Britain, and from the method *a tire et aire*, previously practised in France, resembling in some respects the method adopted with plantations of coniferous trees in Scotland, the following details are given in view of its application to the different species of pine trees grown on the sand-wastes of France.

And on the assumption that it may be more acceptable to my readers, as well as in more perfect keeping with all besides advanced in the volume, that I should give the natural history of the trees mentioned as this is given in France than as it is given elsewhere, I shall follow this course.

Of the *Pinus Sylvestris*, the *Pin Sylvestre* of France, M M., Lorentz, and Parade, wrote in a volume entitled, *Cours élémentaire de culture*

des Bois créé a l'Ecole Forestière de Nancy. "This tree, the *Pinus sylvestris*, of Linnæus, is known under numerous names—the wild pine, the pine of the north, of Riga, of Hagenau, and of Geneva, the pinasse, &c., and it is one of which the red pine or Scotch pine is only a variety, recognisable by its shorter leaves, by its cones being smaller and grouped in whorls, and by the reddish tinge of its young shoots. It constitutes the principal tree in a great many forests of considerable extent in which it is found mixed with the oak and birch.

"*Climate, Situation, and Exposure.*—The temperate climates are those in which it manifests greatest vigour of growth; but cold countries are not inimical to it, for in the north of Europe, in Russia more especially, and in Sweden, it acquires most valuable qualities and dimensions, and by itself alone covers great extents of country. It grows on the plain as well as on slopes; but high elevations do not suit it. In these situations the snow and hoar-frost accumulate in great quantities on its leaves, and that to a greater degree than on the other resinous trees of cold countries, whereby often branches are torn off, and sometimes the trunk itself is broken.

"It succeeds on all exposures, not exclusive of the full south, when it is undertaken to replenish wide spaces, or deteriorated forests with a south exposure. It is a tree greatly in demand, not only because it is satisfied with a poor and dry soil, but because the young plants better sustain the sun's heat than do those of the other coniferae." But they remark that in saying this they are only speaking of the more temperate districts of France; that the departments in the south of France have other trees which grow there, such as the maritime pine, and the Alleppo pine; and that it is probable that the *pin sylvestre* would succeed ill there unless at elevations at which the heat is less intense. It is mentioned that in the Pyrenees it is found at an altitude of 1,200 mètres.

"*Terrain*, or Soil.—It demands a deep light soil, it is found even on sand entirely devoid of cohesion, and the wood produced on such ground is of better quality than is that grown on more substantial soil; compact earths are unfriendly to it; and, although it does succeed on marls, its growth on these is much inferior to what it is on silicious ground.

"It is sometimes found on moist and turfy spots; but its vegetation there is in a languishing condition, and it there presents itself ordinarily in so peculiar an aspect that it has been taken for a totally different species of tree.

"*Flowering and Fructification.*—The flowers are monœceous; they appear in April or in May, according to the temperature.

"The strobile or cone remains very small during the first year of its appearance. In the following spring it begins to enlarge, and it attains its full development towards the end of summer. It is ripe in the beginning of November; but it does not open its scales to allow the seed to escape until the spring following, so it requires in all at least eighteen months to ripen, or about two years to mature and drop the seed.

"The first warmth of the spring acts on the cones; the scales open without detaching themselves from the axis, and thus they allow the seed to escape; this is small and winged.

"The tree attains its complete fertility towards the fortieth year of its age; the fruit appears about every two or three years.

"*Young Plants.*—These are very robust from their first appearance; but they do not stand a protracted shade. In general they may be reared without shelter; but on ground which is very dry, or with a complete southern exposure, it would be beneficial to have them shaded during the first year of their growth.

"*Leafage.*—The leaves are somewhat long; but as they rarely remain on the tree above three years, it follows that it creates only a lightish shade.

"*Roots.*—These are strong and disposed to bury themselves. When the soil permits the tap-root descends a mètre or more, although a less depth can suffice to ensure the tree a pretty fine vegetation. In ground which is moist, or poor, or deficient in depth, the tap-root disappears almost entirely, and the lateral roots run along the surface and manifest a disposition, as do some other coniferae, to introduce and fix themselves in the fissures of rocks; but this superficial growth of the roots is not so favourable to the growth of the tree.

"*Growth and Longevity.*—The vegetation is very rapid from the first years of its growth; when the soil is adapted to it, it lengthens sometimes in its youth a mètre or more per annum. It lives for 200 years, and attains to a height of 33 mètres and more, with a diameter of from 1 mètre to 1 mètre 20 centimètres at the base."

I have met with few trees more extensively diffused over Europe than is this. I have met with it in different countries under different names, but the tree was the same, and the botanical designation everywhere the same. The specific sameness of varieties or subvarieties presenting very different appearances, has been demonstrated by M. de Vilmorin, on property belonging to him at Barres, in the

department of the Loiret, which is now maintained by the Government as *L'Ecole Forestière des Barres.* This, strictly speaking, is a Forest School; while that at Nancy, strictly speaking, is a School of Forestry.

The designation *Ecole Forestière*, or Forest School, was given to the establishment apparently in contradistinction, on the one hand, to *Nursery*, a designation borrowed from domestic life; and in contradistinction, on the other hand, to a plantation or forest, it being a collection of trees raised from seed obtained from forests, or from nurserymen and seedsmen of note, and reared with a view to the study of their habits, their identity, and their differences.

The design of M. de Vilmorin and the results of his operation we learn from himself. He died in March, 1862, a venerable man, full of years and of honour,—*Membre de la Société Impériale et Centrale d'Agriculture de France*, and *Correspondent de l'Institut.*

The *Bureau de la Société d'Agriculture*, in collecting documents, of which they might avail themselves in preparing a historical notice of their honoured colleague, learned that he had written a history of his experiments, and procured from his family a copy of this document, with permission to publish it in their memoirs.

In the introduction to this record, which related exclusively to this establishment, which was only one of many experiments and related researches with which his valuable life was occupied, he says:—"The work or treatise, of which this is but the first part, has for its object to report collected observations made during a long course of years on the trees composing the *collection forestière*, which I have made on my estate of Barres. Studies of this kind have at this day a much greater interest for France than they ever have had before.

"The forests which, in a former day covered a great part of her territory, are, if not entirely destroyed, at least so much reduced that the products are far below her actual requirements.

"For a long time now France has been dependent on the foreigner for a considerable portion of the timber requisite for the maintenance of her navy, and more especially for wood suitable for masts. Throughout nearly the whole of the last century masts for the navy were only to be found in the Baltic ports, and chiefly in Riga, and now that timber of very great dimensions fit for this purpose is only to be obtained at great price, we find it necessary to draw a great portion of our supplies from the United States.

"This condition of things is not only a heavy burden on the treasury, but it may become matter of grave concern in case of eventualities against which it is necessary to provide.

"France, by the single fact of her geographical position, with her two hundred leagues of coast on two seas, with her colonies, and Algeria, and her distant commerce to protect in all parts of the world, cannot avoid being a maritime power of the first order—it is one of the necessaries of her existence. She can no more relieve herself of an imposing naval force than of an army.

"But for the construction and maintenance of numerous vessels of war, it is needful that she be able to find on her own soil the needed timber.

"Those portions of the soil which have been conquered from the forest by agriculture cannot be recovered. But France still possesses considerable resources besides these. For instance, a large extent of the mountains have been despoiled of forests; the re-covering of these with trees is acknowledged by every one to be an urgent and indispensable measure; besides, there are hundreds of thousands of hectares in one district of the west and of the south central France which have continued hitherto in a state approaching utter unproductiveness, which are capable of bearing beautiful timber forests of resinous trees. It is on these lands, and by the employment for the purpose of resinous trees, and more particularly of pines, that we must operate to restore our forests. And it is at this point especially that a knowledge of the different species of pines, and of their principal varieties, becomes important; we may, indeed, according as we employ one or other of these, create on the same soil forests of the poorest or of the greatest value.

"This holds true especially of the *Pinus Sylvestris*.

"In the greater part of the woods of resinous trees formed on a pretty large scale in Maine, in some parts of Brittany, and more recently in Sologne, it is to the *Pinus Maritima* that a preference has been given, because its growth is rapid, successful culture is easily ensured, and the seed is abundant and cheap; but, as is known to all foresters, the *Pinus Sylvestris* is capable of furnishing products infinitely superior in quality, in dimensions, and in value to those which can be obtained from the *Pinus Maritima*. And in connection with this subject there is a question which it is very important should be resolved, it is that relating to the relation of the Riga pine and the varieties of the *Pinus Sylvestris*. The comparative culture, on the same land, of trees, of which it is desired to determine the

identity or the difference, is what I have undertaken and carried into execution, as may be seen by statistical details relative to these species.

"I have brought together, in clumps more or less extensive, according to their importance, the *pinus sylvestris* of every variety indicated by authors, and all those which, by whatever name known, it appeared to me might prove useful in this collection. In regard to the Riga pine, I have not been confined to a solitary lot: independent of seeds which I procured from the north, from sources the most certain, wherever I had knowledge of old plantations in France, known or presumed to have had the same origin, I have managed to obtain seeds or plants which, added to the lots introduced, directly furnished the means of studying further the question.

"These plantations have had for their special object the solution of numerous questions of botany and of forest economy, of which some are of great importance to France.

"Commenced thirty years ago, and with this view, and augmented every year since, they form now perhaps one of the most interesting and most useful collections of this kind in any country. They comprise, amongst other species, an assemblage of more than thirty lots of the *pinus sylvestris*, obtained from as many different quarters and sources, for the study of the varieties of the species, and more particularly of the mast pines, or Riga pine, of absolutely certain origin, planted to admit of comparison with other varieties of the *pinus sylvestris*, by means of which might be cleared away the doubts which have hitherto existed in regard to this tree, so important for naval architecture; an *école* of *pinus mugho*, *pinus pumilio*, and *pinus uncinata*, a necessary complement to the other in view of forest study; all the pines of the series of the *Laricios*, trees of great interest in sylviculture, but trees in regard to which there exists at this time in books great confusion. The clumps of this series constitute one of the most beautiful portions of the plantations at Barres; one variety hitherto little known, the Laricio of Calabria, commands attention by its great vigour and beauty, as does also the Pine of the Pyrenees, a very beautiful tree of recent introduction; a plantation of Cedar of Lebanon, growing rustically among the pines, is thriving well; a collection of the forest oaks of South America, amongst which the most important, such as the Quercitron, the Red Oak, &c., have established themselves in massive plots; plantations of American Nuts, of *Bouleau à Canot*, of the *Alnus Cordifolia*, and of other exotic trees, the qualities of which and their

vegetation on the soil of France cannot yet be known, from the limited numbers under cultivation; plantations of various oaks, particularly schools of oaks of Europe and of Asia, amongst which are worthy of note, *Quercus Fastigiata*, *Cerris*, *Tauzi*, *Aegilops* or *Velani*, in the avenues and borders; some new and remarkable poplars, &c.

"These plantations, if not complete, at least very extensive, will furnish to the man of science and to the practical man great means of study. The opinion, on this subject, of foresters and of distinguished agrinomes who have visited them have almost made it obligatory to publish the results I have obtained; and, having to some extent anticipated this, I fulfil the duty now with the more satisfaction, seeing that my conviction has always been in accordance with that which has been expressed to me. To make plantations of this sort fulfil the design of them, or to have the chance of doing so, supposing they should exist their full terms, it is necessary that the lots of which they are composed should be found with ease and with certainty when those who have created them shall be no more: for this every necessary arrangement has been made."

As has been stated, the one principal object aimed at by M. Vilmorin in the establishment of this Experimental Forest was to determine the varieties of the *pinus sylvestris* and the properties of each, with their adaptation for culture in different districts of France; but other trees received also a large share of his attention.

I had the privilege of visiting the plantation and seeing it under the guidance of M. Henri Vilmorin, grandson of the founder, the honoured representative of three successive generations of noble-minded men, who distinguished themselves in this field of labour.

Of the Scotch Fir *(Pinus Sylvestris)* there were rows of trees, raised from seed or seedlings received from different parts of the Continent and from Scotland, representing thirty varieties or sub-varieties of the tree; and rows of other coniferae, representing the products of nearly a hundred different parcels of seeds or seedlings received from various parts of the world; rows of oaks, representing the products of upwards of sixty different parcels of acorns and seedlings collected from all quarters; and rows, or one or more single trees, representing upwards of a hundred and fifty other hard-wood trees. There were in all some two hundred and twenty-five different species and varieties of trees, and numerous specimens of some of these, selected, some for

their worth, some for their renown, and some for purposes of comparison and experiment; and they were planted alone or in clumps as might be necessary to bring out their characteristic points.

Since the death of M. Vilmorin, the founder, the portion of his estate containing the experimental forest has been purchased by the Government, that it may be maintained as a national establishment.

Of the *pinus sylvestris*, M. Vilmorin reports:—"Of the different questions which I have proposed to myself to solve, by means of the Barres plantations, none is more important from a practical point of view than that concerning the varieties of *pinus sylvestris*.

"At the sametime there is not one on which more contradictory, and sometimes inexact, notions are to be found in books; so I shall be obliged, before proceeding to the direct observations which I give, to enter into rather full preliminary observations in regard to it. It is an unhappy necessity, but circumstances render it inevitable.

"It being of importance that this should be well understood, I shall first speak of the pine and whence it comes. I shall then show the principal opinions advanced on this subject, stopping at those which, establishing errors essentially hurtful in practice, demand discussion; then, lastly, I shall arrive at the special work which is the object of this memoir—viz., the examination of the collection which I have gathered together at Barres.

"The *pinus sylvestris*, the most widely diffused of those which form the pine forests of Europe and the north of Asia, is at the same time one of the best and most useful. Robust, and somewhat indifferent in regard to soil, it succeeds in sands too damp, and in situations too much exposed to frost for the maritime pine, and, by a remarkable contrast, on lime and chalk soils, where the latter cannot live.

"Its wood, strong and durable, at the same time light and elastic, is much used in civil and naval constructions, for it is principally it which furnishes the excellent pine masts of the north, of which no other pine offers the equivalent.

"But with these remarkable qualities this tree has one peculiarity which tends to diminish its value, and which has created much confusion, in reports concerning it—viz., its being liable to change and vary to such a degree that perhaps nothing similar exists in any other species.

"Thus, whilst in the forests of Russia and Lithuania it attains the size of the largest firs, and furnishes admirable trunks, which sell in our ports and in those of England for from 1,000 to 5,000 francs and

more. A large number of the trees which grow in Switzerland and Germany are middling trees, badly formed, often incapable of furnishing even a passable plank; in short, having no resemblance in anything to those of which we have just spoken. This great diversity of the *pinus sylvestris*, noticed in the middle of the last century, has given place to questions and doubts regarding it on which opinions are still much divided. Some have thought that the pine or Scotch fir, as it was then called, did not form a single species as was pretty generally believed, but formed several which had been mistakenly united till then; two or more have been described and named accordingly; others have explained this diversity in the species by the existence of varieties or races which are reproduced in successive generations. Others rejecting every distinction of this nature have maintained that the differences, however great they may be, which are to be seen in the *pinus sylvestris* are entirely owing to the soil, to the climate, and to the influence of exterior circumstances. These contrary opinions have been often reproduced for nearly a century, without deciding the question. It has even become more confused and complicated through the discussions, and it remains still almost entirely yet to be resolved.

"As a fact, it is now almost generally admitted that the species is one, and that of this there are varieties. To every one is known, at least the names, Riga pine, Haguenau pine, and Scotch fir, &c., but if one seeks in books for the differences between these, they are not to be found; there are also vague descriptions, or rather, what is worse, botanical descriptions which, under their precise and scientific form, are inexact and contradicted by the trees themselves, when one tries the application on a sufficient number of specimens which are unlike. Such an uncertainty is evidently troublesome and injurious on an essentially practical subject. It is more so than ever now, when the condition of forests in France naturally entails that the culture of pines should be considerably increased, and that, on the other side, the *pinus sylvestris*, more appreciated than formerly, begins to be associated with the maritime pine, or even to replace it in the construction of composition of woods of resinous trees. It is then evidently necessary to arrive at some notions more precise than those which have existed till now in regard to it.

"The English have advanced far before us in the culture of the *pinus sylvestris*. It is in England also that the remarkable differences between the individuals of this species have been remarked. The first printed notice is to be found in a treatise on forest trees,

published in 1760, by a great Scottish proprietor, the Earl of Haddington.

"Here is what he says on the subject:

"'Although I have been assured that there is only one species of Scotch fir, and that the differences which are to be found in the wood of these trees are due only to their age, and the soil in which they have grown, I am nevertheless convinced that it is otherwise, and here is the reason. When I ordered the pines planted by my father to be cut down because they were too near the house, several men still lived who remembered to have seen them reared. The seed had been sown in the same bed, removed to the nursery, and afterwards planted on the same day. Then I saw that when I cut the trees, I found that some had white and spongy wood, and others red hard wood, and they were examined within a few days of each other. This observation has had such an effect on me that I have ordered the cones to be only gathered from the reddest trees.'

"It is a very remarkable thing that the first observation which was made on this question has pointed out the solution, the truest, in my opinion at least, first as to the principle that natural varieties exist independant of the soil and climate, and then as to the practice, that in choosing between two varieties, the one good and the other bad, only the first should be chosen for reproduction.

"One might say that these two ideas of the Earl of Haddington contain a complete theory and practice in connection with this great question of the spontaneous variation of species applied to the wants of man, and to the advancement of rural economy.

In France, where the question was opened rather later than in England, it has been much more discussed: the botanists have interfered, and each has settled it in his own way. Bosc, in studying the *pinus sylvestris*, thought he had discovered four very distinct types, which he has described as so many species: first, the *pinus sylvestris*, properly so called; second, the Scotch fir; third, the Riga pine, or pine suitable for masts; fourth, that of Geneva or Tartary. This opinion not having been adopted by any one, except in regard to the Scotch fir, I will not discuss it. But another opinion, which it is more necessary to combat, is that which places the *pinus sylvestris* on the one side, and the *pinus rubra* of Miller on the other. It has been supported principally by M. Deslongchamps, and by M. de Candolle. With the authority which these two names give to it, especially that of M. de Candolle, or rather because of this, I feel that I must combat it, being convinced that it is an error.

"The first remark to be made is, that Miller never pretended in establishing his species, *pinus rubra*, to make any distinction from the *pinus sylvestris* of the authors who preceded him; it is only a new name, which, for some reason, he has given to this species. The sentences from Ray, from Bauhin, from Duhamel, which they quote as synonymous, leave no doubt as to this. Nevertheless, the *pinus rubra* of Miller, by a singular error, has been regarded as a second species, made by him in the *pinus sylvestris*. This fact may be explained naturally enough by the following circumstances: At the same time that he established the *pinus sylvestris* under the name *pinus rubra*, Miller almost beside it described another species under the name *pinus sylvestris*, and among the numerous synonymes which he assigns to the latter is to be found *pinus sylvestris*, No. 471, Bauhin, wild pine of Geneva. For all readers, a little hasty in forming a judgment, and there is no lack of such even among botanists, there was here an indication, or even an evident proof that Miller had established two species in the *pinus sylvestris*. Now, when one reads the text even of the article relative to his No. 1, he sees that the latter is no other than the maritime pine, or pine of Bordeaux. In spite of the evidence of this fact, the contrary version has prevailed, and some botanists, having to treat of the pines, have adopted as distinct the two species, *pinus sylvestris* and *pinus rubra*. This basis adopted, it was necessary to find characteristics for the latter; now Miller did not furnish any, as with him the *pinus rubra* being identical with the *pinus sylvestris* of all authors, he had applied to it the characteristics of the latter.

"Hence have come distinctions which I will not call imaginary, for doubtless they are applicable to individuals, but certainly not to all, nor do they possess the generality or the comprehensiveness of specific descriptions.

"This may be judged of by the examination which I am going to make of the characteristics attributed to the *P. rubra* in the new Duhamel and in the French Flora.

"Differences between *P. sylvestris* and *P. rubra*.—Let us quote the new Duhamel:

"First, the wood of the first is rather reddish—no observations to make on this point.

"Second, the leaves are in general of a more glaucous green.

"There are in my plantation several lots of the *P. rubra* of the north, coming from different provinces of Russia, and as well characterised as possible. Their leaves are plainly less glaucous than

those of the common *P. sylvestris* of France and of Germany, planted comparatively near them.

"Third, their cones are almost always arranged in whorls of three, four, and five; according to the same author, in the *sylvestris* they are often by twos. I have many times, in all the lots of *sylvestris* in the school, counted as many cones.

"I have constantly found in all, however different they may be, some individuals with one, two, or three cones, very rarely with four; nay more, this variety is often to be found on the same tree, some branches bearing single cones, whilst on others they are grouped by twos or threes. I have also noticed that this varies decidedly on one tree in different years, apparently according to whether the flowering has taken place during favourable weather or not. This characteristic then is of no use whatever.

"Fourth, the projecting part of the scales form a more decided pyramid in the *P. rubra*, and the lozenge formed by its base has its greatest diameter in the vertical direction.

"In the *P. sylvestris*, on the contrary, the greatest diameter of the lozenge, according to the same author, is horizontal.

"I have made, with a view to recognise the characteristics, numerous examinations of the cones coming from different trees belonging to the two supposed species, and here is what I discovered—first, that the projection of the scales, though variable in both, formed a much less decided pyramid in the cones of the *P. rubra* than in those of the *P. sylvestris*, which is precisely the contrary of what the author says; second, that in the same lot, either of *P. sylvestris* or of *P. rubra*, and sometimes on the same tree, the greatest diameter was sometimes in a vertical and sometimes in a horizontal direction, so that this characteristic is useless as a means of specific verification.

"Fifth, Bosc and De Candolle give as characteristic to their Scotch fir, or *P. rubra*, that it has the young sprouts red.

"Now the most freely planted lots of the red pine of the north in my school are, on the contrary, distinguished by the tender green of their sprouts in the spring. I have besides amongst my lots a considerable number of Scotch firs coming directly from Scotland. The trees in it are extremely varied in character. One finds among them types of all the *P. sylvestris* possible, except the specimens with red sprouts, which, far from being in the majority, are only met with as rare exceptions; the great mass have green shoots.

"Besides, if Miller had recognised this as a characteristic of his *P. rubra*, he would have given it, and he says nothing of it. It is not

then from this that the author must have taken this specific name. Apparently it was for him only a translation and introduction into botanical language of the name of the pine or red fir (red deal), under which it is generally known in the trade, and in the ports of England, and the Baltic, the wood of the *P. sylvestris* coming from Russia and Lithuania. The result of this description is that the *P. rubra* cannot be admitted as distinct and separate from the *sylvestris*."

There follow details of the varieties of trees composing *l'Ecole des Pins sylvestre*, with the observations made. Of these details the following is a free translation in which I have deemed it expedient to alter in some places the order in which some of the trees are described, and to abbreviate or abridge in some cases the details given:

"This collection is composed of all the specimens of the *pinus sylvestris* of different districts and countries I could procure. I sought especially that it should comprise those in regard to which doubts and discussions have arisen, and still more especially those which having received the names of varieties are more generally regarded as distinct. The *Pin de mâture*, or red pine of the north, and those of Hagenau, of Scotland, and of Geneva, have supplied in this respect the first foundation of the plantation; and the first of these *(le pin de mâture)*, mast pines, the red pine of the north, those of Hagenau, of Scotland, and of Geneva, the basis of the plantation. The first of these *(le pin de mâture)* being the most important, is that in regard to which I have exerted myself to multiply as much as possible the means of studying. Through the assistance of my connections, and the obliging co-operation of many French and Russian amateurs, I have obtained from different provinces of Russia, and of Lithuania, celebrated for the production of these pines, seeds, the products of which are to be seen in the plantation. To these lots obtained thus direct from the localities have been added many others produced from plantations made in France, at previous times, the Russian origin of which was well established; and further, with a view to multiplying as much as possible the means of comparison, I have added specimens of the *pin sylvestre* from different parts of France.

"The whole presents a collection of some thirty lots, but to prevent the formation of an exaggerated idea of these, it may be stated that they are not all equal in strength, age, or extent, nor are they in some other respects susceptible of exact comparison; they are on the contrary, unequal in the extreme. Some form masses more or

less considerable, while others consist only of some single trees; their ages range from that of ten or twelve years to that of thirty years and upwards. This inconvenience is inevitable in a creation of a plantation of this kind. To reduce as much as possible the disadvantages of this inequality, I shall take care to indicate in the details given of each lot the differences which may have an influence on the actual appreciation of their character."

In regard to his practical classification of the varieties in l'Ecole, he says: "The differences, be it between individuals or between masses growing together, sufficiently marked to enable one to find on them the distinctions of varieties are of two kinds: those which relate to the appearance and conformation of the tree, and those which relate to the botanic characters furnished by one or more of these characteristics, or to the appearance and conformation of their organs, cones, flowers, leaves, &c.

"Botanists who have taken up this question have in general given a preference to this last basis of classification. This, however, I have not adopted, and that for the following reason: Varieties founded on differences which are exclusively or principaliy botanical, may not be such when viewed from the stand-point of forest economy. Thus, for example, let a *pin sylvestre* have the summit of the scale formed in the manner of that of the *P. mugho*, or have three leaves in place of two in the sheathe of a cone more or less projecting, bent as in a hook; let the greater diameter of the losenge formed by the sides of the cones be horizontal or vertical; let the side of the anthers in the male flowers be more or less projecting—that would be a curious variation, very interesting botanically in being a departure from the general character of the species; but if, besides this, this tree and those reproduced from its seed did not present in their vegetation and in their physical qualities marked differences from those amongst which they were growing, the existence of this variety would remain outside of every useful practical application; it would be only an interesting fact of natural history.

"It is altogether otherwise with distinctions founded on the bearing and conformation or habit of the trees. In these, differences represent qualities or defects, or rather they are, in reality, the one or other. Between a pine of an elongated trunk perfectly straight, with a regular head, and one with a crooked trunk, knotty, with head diffuse and spreading, there is all the difference between a very good tree and a bad one.

"This mode of determining varieties is then one in direct relation with the views of forest culture, and may contribute efficaciously to its good result. It is in this respect one, for our purpose, very much preferable to that of which I have spoken as adopted by the botanist. But this is not its only advantage; instead of minute characteristics, often difficult to catch by the eye without the assistance of a lens, there are thus given characters of an order less recondite, call them even vulgar, if you will, but they are easily caught by anybody and everybody. And, in fine, another consideration in favour of the adoption of them is, that they are at least as constant as those of a nature more strictly, and essentially scientific, or botanical. But by this remark I mean not to condemn these last."

These reasons, says he, have led me to adopt the mode of classification described in comparing together, and grouping according to their analogies, the numerous lots constituting *l'Ecole;* and proceeding to detail the classification of the *pin sylvestre*, in the collection formed and studied by him, he says:

"The direction taken by the branches, according as this may be ascending or horizontal, has ever appeared to me to be the characteristic most generally connected with the good or bad quality of the trees, and I have adopted this as the basis of the classification of the lots.

"From this have resulted two principal divisions—first, that of trees with ascending branches; and second, that of trees with horizontal branches.

"Then, some sub-divisions being still required to bring together trees presenting analogies of secondary importance, and to obtain groups less comprehensive, I have introduced three into the first and two into the second of these grand divisions, and these give the following five series or divisions:

"I. Branches ascending corresponding to *P. sylvestris var-rubra.*

"A. Ascending, close, and pyramidal branches.

"B. Ascending, scattered branches, with a regular crown.

"C. Ascending, scattered branches, with an ir-regular crown, and the branches often *gourmandes*, or overgrown, as if feeding rapaciously on the sap of the tree.

"II. Branches horizontal corresponding to *P. sylvestris var-vulgaris.*

"D. Horizontal branches in successive tiers or stages.

"E. Horizontal branches, thick-set and regular."

These five divisions correspond to local varieties generally recog-

nised; and he gives again the same divisons under the names of these as shorter and more precise:

"Ascending branches.

"A. *Pin de Riga, pyramidé-elancé*, elongated tapering pyramidal.

"B. *Pin de Riga, pyramidé-élarge.*

"C. *Pin d'Haguenau; Pin d'Allemagne*, irregular expanded pyramidal.

"Horizontal branches.

"D. *Pin de Genève élancé-etalé*, tapering, but straggling.

"E. *Pin de Genève ramassé, Pin des Hautes Alpes, ou de Briançon*, thick-set and compact."

Of the first of these types, the *Pin de Riga pyramidé elancé*, elongated tapering and pyramidal, he gives the following characters:

"The trunk is very vertical, sustaining well its great size, often almost cylindrical through upwards of half its height. The branches, of moderate strength, manifestly of equal growth amongst themselves, form a series of regular and symmetrical crowns the *tout ensemble*, of which, by its pyramidal form, recals the habit of the Italian poplar. The bark is of a decided reddish yellow, from 1 or 2 mètres above the base."

Under this type he places in his *pinetum*, pines raised from two different parcels of seed of the Riga pine, received by him from Russia, and a Witepsk pine, raised by him also from seed received from Riga.

Of this he writes:

"Of the different lots which I have received directly from Russia, the Riga pine, raised from seed furnished by M. Zigra, is that which offers the most complete type of the elongated tapering pyramidal variety. The mass presents the following characters: The trunk is in almost all perfectly vertical, sustaining well its great bulk, and it is often almost cylindrical throughout half its height or more, the crown is regular and symmetrical, composed of branches somewhat strong, and of manifestly equal growth; the general form recalling the habit of the Italian poplar. The bark is of a decided reddish yellow from about 1 or 2 mètres from the ground, and scaling off; that of the base is not so good, and it is not so rent with cracks as is the case in the greater part of the other lots.

"The shoots are more forward in spring than those of the Haguenau, and much more, to the extent even often of fifteen days, than those of the Geneva pine, the pine of Ardèche, and their analogies. It is of a pale green and in no way of a reddish hue, the leaf is not so glaucous,

not so long, and not so straight as that of the Haguenau, and it stands more erect against the branches.

"It is, on the contrary, longer and narrower than are those of the Geneva variety.

"The cone is smaller and shorter than that of some others, more particularly than that of the Geneva pine and some of its analogies; it is generally grey, and sometimes, but rarely, of a somewhat purplish hue.

"The bud or young shoot varies in hue from yellowish to reddish—it is smaller and less resinous than it is in the greater part of the lots of the varieties having horizontal branches; the colour of the male catkin varies from a yellowish hue to that of a pale red."

Of Riga pines, raised from seed obtained from Riga through M. Helmond, he writes:

"This is identical, or almost absolutely so, with those just described, with which I could with all propriety have united it, but I mention it apart, because it forms on the grounds separate very marked clumps of trees, of the same origin, but of different years' growth; the proportion of trees with scattered branches, or even horizontal ones, is much greater than in those just described. I shall have occasion to revert to this fact of which the Russian series of pines presents other examples."

In 1838 he writes: "M. Wagner, nurseryman and seedsman in Riga, sent to me some cones produced in four of the provinces of Russia known to furnish beautiful pine masts. Although the trees raised from them are few in number and younger by ten or fifteen years than my older Russian pines, I consider that I ought to classify them, provisionally at least, according to their actual appearance." And of one of these lots, that of the pine of Witepsk, he says: "By the regularity and the very decided ascending direction of its crowns, and by the *tout ensemble* of its characteristics, it belongs evidently to the section of the elongated tapering pyramidal varieties; it will probably prove identical with the Riga pine first described.

"Intermediate between this class and the second, are the Smolensk pine, the Wilna pine, the Tschernigoff pine, and the Volhynia pine from another province of Russia, Riga pines raised from seeds collected at Barres from trees raised from the first mentioned parcels of seeds received from Russia, and a pine tree raised from the seed of a pyramidal tree at Verrières, near Paris, which, from its port or bearing, might be included in the first section, and from its bark in the second."

The second division is described under the head of the expanded pyramidal Riga pine, of which he writes:

"The principal characteristic by which this section differs from the preceding consists in this, that the branches, longer, stronger, and more separated from the trunk, form a more expanded pyramid. The trunks in the greater part of the lots of this series are larger at the same age than those of the elongated pyramids, and they are at least as high; but the proportion of trees perfectly straight and regular is less than in these. The colour of the bark is also less uniformly reddish. In fine, in the *tout ensemble* of their characters the natural grown trees are less elegant, less perfect in general in their proportions than those of the elongated pyramids, but more vigorous, and appeared destined to acquire greater dimensions; it is amongst them more especially that we should find trunks of the exceptional dimensions, which serve for masts to vessels of the first rank. They present then, in this respect, as much interest as do those of the first section."

The pine of Smolensk was raised from some of the cones obtained from M. Wagner. "This," says M. Vilmorin, "was distinguished from the others thus obtained in having the direction taken by its branches very much diversified. Of the nine individuals of which the lot consists, three have these horizontal, and very prolonged; of the six others, two are excellent types of the elongated pyramidal series, and four belong to the series of regular expanded pyramidal form. Notwithstanding these differences, all, with perhaps one or two exceptions, present thus far the essential characteristics of the best *Pins du Nord*, the trunk is clean and elongated, the crowns regular, the bark, in fine, is thin, delicate, and of a decided reddish colour.

"The mixture of trees with horizontal branches," he adds, "gives to the lot, limited in number though it be, a particular interest for subsequent study."

Of the Wilna pine, raised also I suppose from the seeds supplied by M. Wagner, there were only seven specimens. "Their crowns," writes M. Vilmorin, "are in general regular, but they are manifestly stronger, larger, and more clothed with leaves and branches than is the case with any which have been yet described. The base of the trunk is more clumsy and covered with a bark more brown and more cracked; altogether, it is a very vigorous pine, but one which, if an opinion may be based on the observation of a number so small, will furnish a smaller proportion of perfectly regular trunks than will these already mentioned.

"Its proper place should have been towards the end of section B, amongst those which constitute a connecting link between that section and the pines of Haguenau (section C, with crowns too irregular for comparison with one another), but I have thought that it would be better to keep together all the lots obtained directly from the Russian produce."

The pine of Tschernigoff is another of these. The lot consists of 12 trees, generally good or very good. They come near to the Witepsk pine, and I had, says M. Vilmorin, in my first verifications placed them next in order amongst the elongated pyramidal pines, but their crowns, although remaining regular, having latterly assumed more strength and extension, the tree finds or would find now a more appropriate place amongst the expanded pyramidal shaped pines of which it may be taken as one of the good types.

Of the pine of Volhynia, he writes:

"Volhynia being one of the Russian provinces, which, according to information for which I am indebted to M. de la Roquette, furnishes the most beautiful pines for masts. I am delighted to have met personally with a proprietor from that country, M. Camille Petrowski, an enlightened and obliging amateur student of the pine, who has kindly sent to me seeds from the district.

"The trees raised from these are by far the youngest of those raised from seed received directly from Russia. They have now been but ten years planted, but it may already be foreseen that they will be amongst the best in the collection. In the first years of their growth they presented so striking a resemblance to what had been the appearance of the Riga pines already described when they were of the same age, that I had then no doubt of their being of the same race; but within the last two or three years they have begun to assume an aspect peculiar to themselves. From having an appearance of feebleness and suffering, which they presented at first, they have become extremely vigorous, their leaves have become greatly elongated; their tint, which was of a pale green, has become on the branches of the year's growth of a decided glaucous shade; and many, the first crowns of which had been very symmetrical, have produced of late years very vigorous feeders, *gourmandes*, and this to such an extent as to show a tendency to deform the trunk.

"I attribute this change to this, that the roots must have passed through the bed of pot clay, which is very near the surface in this

ground, and come to a sandy sub-soil, eminently favourable to their growth; it may be also attributed to this, that, planted as they have been in a long row directly facing the south, this position may have helped to give to one portion of the branches an extraordinary development. Notwithstanding these unfavourable circumstances, the greater number have thus far preserved in their trunk, their crowns, and their bark, the characteristics of the best *Pin du Nord;* and in view of everything, while regretting much that they have not been planted in a close clump, I do not doubt that one portion of them at least may one day be the most beautiful *pins sylvestres* in the school. On the other hand, this lot will be all the more interesting to examine in their after growth—that it exists in sufficient extent to supply studies somewhat conclusive; it comprises about 400 trees."

Under this second head he classes a Riga pine raised from seed which had been sent to him by M. Noel, gardener of the *Jardin botanique de la marine,* which had been gathered on a plantation at Guiparaz, near Brest, which again had been raised from seeds brought from the north in 1802 by an officer of marine; a Riga pine raised from seeds brought originally from the north by the late M. Pennanech, of Morlaix, with which he formed a plantation on his property at Bretagne; a Riga pine from seed raised by M. Pousson, d'Hollande of Bergerae; a Riga pine from seed raised by M. Batelat, of Vie; and trees of *P. sylvestris,* raised from the seed of a tree in the garden of M. Picot-Lapeyrouse.

Of Riga pines, raised from seeds yielded by trees grown from seed obtained from Russia, he writes:

"When my Riga pines, raised from seed obtained directly from the forests, began to yield seeds, I caused these to be collected, with a view to ascertain whether the race would reproduce itself with its peculiar characteristics. The plants which have been thus produced, though they cannot be yet judged with certainty, have in general a decided analogous appearance to that of their parents. A certain number, however, presenting some defects in the trunk, or having their crowns too strong, I do not wish to place them in the first series, but would rather put them provisionally in the second series, which contains many lots which are still young, and upon which an approximate judgment only can be formed. Whatever may be the definite place of these, the mass promises thus far to be very good."

The second series, Riga pines of expanded pyramidal outline, have the branches ascending and spreading, and the crown regular.

Of the first of these, the Riga pine, from a plantation at Guiparaz, near Brest, of which there were in the school several clumps, he says: "Their trunk is in general very vertical and elongated, but the branches are perceptibly longer and stronger than are those of the first and second mentioned Riga pines, described as of elongated pyramidal outline. The crowns are, however, regular in the greater part of them. The red coloured bark begins a little higher than in the elongated pyramidal series. It is of a tint rather more pale, but sufficiently decided to show that the pine certainly belongs to the red pines of the north. It is, moreover, remarkable for its great vigour, and it constitutes in its *tout ensemble* one of the good samples of a variation from the elongated pyramidal type. The leaf is longer and more glaucous than those of the specimens referred to, and resembles somewhat those of the pine of Haguenau; the cone also is more elongated and narrower in the upper half."

The Riga pine, furnished by M. Pennanech, is like the last, a pine of Russian origin, raised by culture in Brittany, and resembles it in most particulars. It differs from it chiefly, that amongst the trees raised horizontal crowns are more numerous, and the bark is more uniformly and more decidedly red in hue, and it approximates that of the two first mentioned.

During the first years of growth the lot of Riga pines had a marked resemblance to the Scotch fir, obtained from Aberdeen, which will be afterwards described.

Amongst the variations seen in the lot, which are numerous, more particularly in regard to the direction of the branches, one meets here and there individuals which are perfect models of the elongated pyramidal type. Altogether, the mass is very good, notwithstanding the want of uniformity which has just been noticed.

Of the Riga pine from Bergerae, he writes: "The sowings of Russian pines, made by M. Pousson, de Hollande, on his estate near Bergerae have been known long from the mention made of them by M. Delamarre, in his work entitled, *Traite Pratique de la Culture des pins*. His son has had the kindness to give me seeds gathered from the trees thus raised, and it is of trees produced from these that I write. These pines, planted in 1840, cannot yet be classed with certainty. They are very vigorous, too vigorous even, and belong probably to that variety of the *Pins du Nord*, which seed, through excess of strength, and tend to approximate this race to that of Haguenau. The proportion of regular specimens in that is at all

times, as at present, sensibly greater than in this. This lot, when it shall be older, it appears to me, is likely to approach nearly in its quality that of Guiparaz."

Of the *pin sylvestre*, supplied by M. Picot-Lapeyrouse, M. Vilmorin writes: "This lot, which does not consist of above a dozen of trees, though not numerous, deserves a somewhat detailed notice in consequence of the interest attaching to itself, and of the uncertainty attaching to its forest origin.

"At a time when I was much occupied with researches on the genuine *pinus uncinata* of Raymond, I addressed myself amongst others to M. Ferrières, chief gardener of the botanic garden at Toulouse. He replied that he could certainly procure it for me, seeing that in the garden of M. Picot-Lapeyrouse there was a tree of this species brought back by that botanist from one of his excursions in the Pyrenees, and which was producing cones. I accepted his offer, and he sent me some. These cones resembled in every respect those of the *pinus sylvestris;* but I sowed them, and, when the plants made apparent that there must have been a mistake somewhere, I planted a row of them in the school. The trees, which are now twenty-eight years of age, and about 15 mètres (50 feet) in height, are very beautiful red pines of the north, and of the section expanded pyramidal. They resemble much the Riga pines of Guiparaz, to which they may be likened.

"Notwithstanding the disappointment which they have occasioned to me, I have always felt a great interest in these trees, and that more especially from the question to which their first origin has given rise. It may be supposed that the tree in the garden of M. Picot-Lapeyrouse had been brought by him from the Pyrenees, as believed by M. Ferrières, in which case it follows that on some place on these mountains there were *pins sylvestres*, in every respect like those of Russia, and belonging to the same race. If, on the contrary, the tree was produced from a plant of the *Pins du Nord*, received by M. Lapeyrouse, it matters not whence, (he had, as director of the botanic garden, widely extended connections with establishments of the same nature, and with amateurs), the consequences which would follow would not be less important, namely these: that a pine of this race, planted and reared in the climate of Toulouse must have so preserved sufficiently its original character, that trees produced from it are at this day in the plantations at Barres bearing comparison with the good lots produced directly from Russia.

"These questions, it may be seen, touch closely upon practical applications, and so warrant my pausing to give these details.

"It so happens that an accidental circumstance adds to the interest awakened by these pines. They are planted contiguous to a small clump of 'pines of Briançon, or of the High Alps, to which they present a most striking contrast. A glance at these two clumps planted on the same day would suffice to convince the most incredulous that there exist of the *pin sylvestre* well marked varieties, independent of the differences due to the effects of soil and of climate."

Intermediate between this class and the third class he places a *pin sylvestre* from a plantation near Louvain, presumed to be of Russian origin. Of this he writes: "The seeds from which this lot was produced were sent to me by an amateur at Louvain, M. Stuppaert, as the produce of a very beautiful plantation, the produce of seeds brought from Russia. The character of the trees confirms the probability of the account.

"Of two parcels sent to me at different times, one has produced trees which stand much too far apart, occasioned by numerous blanks, which are veritable Haguenaux, of a very strong trunk, but often deformed by enormous overgrown branches; the other, sown where they grow, has, on the contrary, generally the trunks very straight and elongated, well proportioned, the crowns also large and strong, but symmetrical, and the bark fairly reddish; in fine, the characters of those *pins du Nord*, which the excess of vigour renders very unequal, but which evidently belong fundamentally to the race; and therefore the tree has found its place in this series."

Intermediate between the same class, and the fourth class, he classes a Scotch fir, the seed of which was furnished by Mr James Reid, of Aberdeen; and another, the seed of which was furnished by Mr W. Malcolm, and a *pin sylvestre*, from the seed of a tree with semi-horizontal branches growing at Verrières, near Paris.

Of the first of these he writes:

"The Scotch fir ought necessarily to make part of the collection of which I am here giving a report, since it is considered the type of the species, at least it is that which has furnished the common name under which for a long time it has been known, a name still much used, especially in England. I have accordingly obtained seeds and plants from Scotland. These have not by any means all

grown. The principal lot has been raised from seed furnished by Mr James Reid, a highly esteemed nurseryman in Aberdeen.

"Of all the lots of *sylvestris* in the school, this is perhaps the most difficult to class. It does not conform itself well to any of the divisions which I have established. It shows an intermixture of elongated pyramidals, but these in but a small proportion, and of expanded pyramidal, some regular, others with strong *gourmandes* crowns, and finally, of those of the race of Geneva, with horizontal branches; the bark in a pretty great number of specimens is of a questionable red mixed with grey, a slightly preponderating proportion approach more to the expanded pyramidal type than the others, and those I class amongst the last lots of that division, in which I have been influenced by this, that notwithstanding the extreme diversity seen in them the Scotch firs have pretty generally the vertical trunks, and the crowns of these, though strong, are rarely deformed by *gourmandes* as in the Haguenau. In regard to quality this is upon the whole rather good than bad.

"Such is the estimate as exact as I could form it of the principal lot of Scotch firs at Barres. I must however repeat what I have said elsewhere, and speaking only of those trees which I have under my eyes, I do not intend by any means to express an opinion in regard to all the pines on Scottish soil, nor even of those of the county of Aberdeen whence these were obtained."

The Scotch firs, raised from seed furnished by M. Malcolm, and also lots, consisting one of the ordinary pines, and the other of the horizontal pine of Europe, which he has classed here, were all too imperfect to warrant the expression of an opinion in regard to them.

Of the trees raised from the seed of a pyramidal specimen grown at Verrières, and of another lot which he has classed among the lots intermediate between the first section and the second connecting itself with the first by its habit, and with the second by its bark, he says:

"These were planted with a special view to determine by experiment if the natural variation seen in individual trees would reproduce themselves in their descendants in proportions so considerable that there might be deduced from this useful applications in practice. It is generally so in nature, but all species do not comport themselves absolutely the same in this respect, and one cannot be assured in regard to how it will happen with each but by direct proof.

"This I had in my power to try with two trees of very different

habits which I had under treatment in a garden at Verrières near Paris; the one forming a pyramid a little heavy and spreading, but going up well and regular; the other, extending its branches horizontally in such a way as to leave the trunk bare between the crowns. I caused to be collected and sown separately the seeds of these two trees, and their produce, planted opposite each other, are now to be seen in the school. Both have preserved their original characters in a very marked degree. Two thirds and more of the individuals have the crowns ascending and pyramidal in the first lot, while they are horizontal and spreading in the second. This result being by much the most interesting aspect of the experiment, I shall enlarge but little on what concerns it beside.

"The pyramidal pine, from Verrières, presents generally good and promising trees, with a straight trunk and a regular crown; the bark is only one degree less marked than on excellent Rigas, which approximates it to the pine of Guiparaz, or perhaps still more to selected specimens of the Scotch fir, raised from seed supplied by Mr Reid."

The third series, the German pine and the pine of Haguenau, is characterised by having the branches ascending and extended, the crowns irregular, and the branches often overgrown *gourmandes*.

Of the typical tree of this series he writes: "Though more vigorous than those of the preceding series, the Haguenau pine is not so good as they. Its crown is too dense and too strong, often intermixed with overgrown branches, which tend to destroy the regularity of its trunk. It also frequently shows knees or defects which greatly diminish its value.

"The bark is reddish in most specimens, but it is not so uniformly so as it is in the first section, or even as it is in the greater part of the lots in the second; that of the base is more brown and more rent.

"The leaf is longer, more glaucous, and less pressed against the twig than that of the elongated pyramidal section. The bud is less forward in spring by eight or ten days."

Under this third head he classes a pine from the forest of Haguenau a *pin sylvestre* from Darmstadt, and a *pinus sylvestris maritima* received also from Darmstadt.

Of these he writes:

"There are many clumps produced from seed obtained directly from Haguenau, some sown, others planted, from 1823 to 1831.

"The characteristic feature and the principal defect of the Haguenau pine consist in excess of vigour, and, above all, of a vigour ill distributed, which is carried often into the branches, to the detriment of the trunk. It is in this that it differs essentially from the true Riga pines. Its trunk is in general much less vertical and less regular, often crooked, warped, or abruptly falling off in size, in consequence of the enormous overgrown branches, which grow out to a great distance, and destroy all regularity in the tree. In one variety which is often met with the tree is more compact, and the general habit more regular; but the crowns, much too strong, transform the summit into a pyramid excessively dense and bushy, in the middle of which the trunk is almost lost. On the other hand, the reddish colour of the bark is less uniform and less decided than in the good lots of the Riga pine; it commences generally 1 or 2 mètres higher; pretty often indeed the bark throughout the whole body of the tree is grey, or much mixed with grey rather than reddish. That at the base of the trunk is more brown, more thick zoned, and more full of rents.

"Such are in general the Haguenau pines in the school of Barres. And from this it may be seen that this variety is not identical with the mast pine of the north, as has been thought by Bosc, and many foresters with him; and that, on the other hand, notwithstanding its superiority in vigour and in rapidity of increase, it is much inferior to it in quality.

"Truth requires it should be stated that there are to be found in the mass of the Haguenaux some individual trees which constitute an exception to the rest, being quite regular in trunk and in crown, with a bark fairly red, and retaining, at the same time, the superiority of vigour belonging to the race. These may be compared to the best pines of the north of the series of strong crowns (those of the elongated pyramids). Also, when one shall come—if that happen—to create, by choice of individuals, the best possible races, certain varieties of these may present, at a pinch, very good points of departure from the characteristics of the most to lead to that result.

"Independent of the differences which I have indicated above, the pine of Haguenau is distinguished from the Rigas, and from those more especially of the first series, by its having the leaf longer, more spreading from the branch, ordinarily a little curved or rounded off, of a more glaucous green about the shoot, and later in spring to the extent of about eight days. The bud is a little more coloured,

the cones of a less uniform grey, often of a slightly violet coloured tint, dull or reddish; but the characters, be they taken from the buds, be they taken from the cones, are not sufficiently marked, nor, above all, sufficiently constant to furnish good means of distinction—at least I have not found them such.

"It is then essentially on those characteristics which I have given above that I have founded my separation of the Haguenau from the Rigas, and made it the type of the third series.

"Of the *pin sylvestre* of Darmstadt some were sown in 1831 and others planted in 1838. They have the same faults and the same qualities as the preceding; form disorderly and irregular; trunk thickened and vigorous, but often knotty and deformed by *gourmandes;* the bark scarcely red, sometimes even grey, throughout the whole height. As in the Haguenau, so in this, there are individuals exempt from the faults of the mass, and promising for the future very fine and good trees, or which are such already; but these are few in number.

"Of the *pinus sylvestris var-montana*, received also from Darmstadt, a row was planted in 1833.

"These, from their descent, and the greater part of their characters, it appears to me, cannot be classed otherwise than amongst the Haguenau, but in a rank below both of the preceding.

"Although their crowns may be less *gourmandes* than theirs, their trunk is still more faulty—not so large in the first place, and very much bent in half and more of the trees, and the bark is grey or brown in almost all. This pine is one of those which show clearly that there exist local varieties and bad varieties of the *pin sylvestre*, which it is of importance to avoid in the formation of woods of this pine."

Intermediate between this class and that which follows, he places a *pin sylvestre* from Champagne, of which he writes: "Two rows were sown in 1831. The seeds were given to me by M. le Vicomte Rinnard, one of the principal planters of pine forests on the chalk soils of Champagne, and were the produce of these plantations. The trees produced from them have not the character of the race, and cannot be classed in any one of the series which I have established. At first sight they look like a mixture of not very vigorous Haguenau pines and pines of l'Ardèche. Examined more closely, it is seen that the greater part are rather intermediate between the two. In regard

to trunks, crowns, and bark, they are in general rather passable, or mediocre than good, or very good."

The second grand division consists of those with horizontal branches,* among which we find the fourth section, designated the horizontal tapering, of which the type is the expanded elongated pine of Geneva, of which M. Vilmorin gives the following characteristics:

"The branches, spreading horizontally, sometimes even depressed; generally very much elongated and flexuous; united in regular crowns, which leave the trunk bare in the intervals between these. This is rarely very straight; the curvations not so acute as on the Haguenau; but, on the other hand, its *grossessement* is much less.

"The bark is tolerably red in some of the lots of this race, but more commonly grey, or very much mixed with grey.

"The leaf is larger and shorter than in all the preceding series. The bud in spring later by from eight days to a fortnight in expanding."

Under the fourth head, the horizontal elongated but straggling Geneva pine: a section of the trees having horizontal branches, he classes—The Ardéche pine; the Geneva pine; the Tarare pine; the *pin sylvestre du Maine;* pines raised from the seed of a specimen, having straggling branches, growing at Verrières; a *pin sylvestre*, given as a Riga pine by M. Leblond, of Bordeaux; and a *pinus sanguinea*, received from M. Barthude, of Toulouse.

Of the three first mentioned he writes: "Though of different ages, the first sown or planted in numerous masses from 1823–1831, the second planted in mass in 1840, the last planted in row in 1833 and 1835, they have always appeared to me identical; I include, therefore, the whole in the same description. I give the preference to the Ardèche pine, because, being the eldest of the three, and by far the most numerous in the school, it best represents the series to which it belongs, and may therefore give of it the best idea.

"The trunks in this race are in about half of them pretty straight and elongated, but too much swelling out and drawn out in rat-tail form. The other half present knees more or less decided, but less strongly so, than in the bad types of the Haguenau pine, and in the *sylvestre* of the High Alps previously described. The branches, excepting those of two or three of the higher crowns, are very generally horizontal, and

*Corresponding to the *Pinus Sylvestris Vulgaris.*

at times even declining, not very strong, very much elongated, and often flexuous; those of the inferior stages almost naked, ramifying themselves in feeble twigs, which carry at their extremity little tufts of short and outspreading leaves, while those of the ascending branches are, on the contrary, very closely pressed towards the branch. The crowns, by reason of their being somewhat equal, are in regular stages, so that they show the trunk bare between them.

"The bark is in general more grey than red, very often of an undetermined shade between the two. That of the base is manifestly less thickened, less brown, and less rent than that of the Haguenau. In regard to enlargement, this pine is inferior to the Rigas raised from Russian seed, and much more so than some of the Rigas raised from French seed, but, above all, than those of the lot of Haguenaux, which, at the same age, have almost double the magnitude; and its increase in height is in a similar measure less than in all those named. It does not, in this respect, surpass any but its analogue the pine of Briançon, to be afterwards described.

"A botanical character, somewhat constant in the pines of this series, is, that the leaf is shorter, broader, and firmer than in the others, and especially than in the Haguenau. Their bud in spring is behind that of these, and especially that of the Russian pine, by from eight days to a fortnight.

"The exceptions to the general characters, which I have just noted, consist principally in the following: A small number of individuals are elongated pyramidal, and as regular as some of the best Riga pines first described; others somewhat more numerous are expanded pyramidal, some regular, others with strong *gourmandes* branches. The individuals of these variations, almost including the last, have a pretty marked advantage over the others in regard to increase in height, but more in regard to enlargement of trunk; the bark of these is not sensibly better than in the mass. There are found here and there, but far separated, trees of which the bark is of a marked and uniform reddish tinge; but this exception is not more frequent amongst the pyramidal than amongst the horizontal.

"To sum up the whole, the Ardèche pine is, or at least appears for the present, inferior in every respect to the red pines of the North, both those raised from Russian, and those raised from French seed. It does not nearly equal in value the Scotch fir, so unequal as these are compared with the Haguenau; this may be doubted, because it is exempt from the great defects of that race, but it has not the good qualities of that tree; and, in view of the whole, the first appears to

me, in default of a better, preferable for most cases, and that more, especially when it is proposed to plant or sow the *pin sylvestre* in poor dry lands, whether sandy or chalk."

Of the *pin sylvestre du Maine*, of which there is a clump in four rows planted in 1830, he says:

"The *pin sylvestre* does not exist in Maine but as a cultivated tree, and the plantations of it which are there met with have necessarily diversified origins, and do not constitute a local race. But the desire of multiplying the points of comparison led me to plant one lot of them, for the seed producing, which I am indebted to the obliging disposition of M. Vètillard.

"These pines belong to the race of Ardèche and of Geneva, but they present a very large proportion of good, and of pretty good, trees, and the bark is more frequently of a pretty decided reddish grey. It is a good type of the race, apparently improved in Maine by successive selection of individuals."

Of the *pin sylvestre*, raised from the seed of a specimen with spreading branches, existing at Verrières, of which there were four rows planted from 1832–1835, he says, in reference to the account given of his design in planting these, and others of a pyramidal form, that this also has produced many trees like the parent. Those of this lot have the decided characters of the Geneva pines; the branches of almost all are horizontal, the bark grey, or very little reddish; they are further pretty vigorous, and are of the number of those which promise to be the best of this series.

Under the fifth head, the Thick-set horizontal pine, he classes a pine from Briançon, and a Scotch fir obtained from Mr. Lawson, of Edinburgh.

Writing of the Briançon pine of the High Alps, of which he had planted three rows in 1826, he says: "The tree, which constitutes by itself the fifth section, was given to me by M. Faure (of Briançon), who had the kindness to get seed gathered for me, as being the *Pinus suffis* of the Briançonnais. This should have been—if Duhamel be not misled in the application of the name—a *P. mugho*. But, be it a mistake of Duhamel, or of the men who had gathered the cones, the pines produced from this seed are true *Sylvestres*. On this point I have no regrets, for I am thus supplied in my collection, with the two extreme types (this and the elongated Riga pine), which exist in

the species of *pinus sylvestris*, a comparison of which shows most manifestly the existence of local varieties and the necessity of distinguishing them. A trunk, thick and knotty, and thick-set, covered with a bark, coarse and much cleft, brown in the lower part, and grey on the rest of the tree; the crowns horizontal, very much drawn together, lining the tree from its base, composed of strong branches often flexuous, which famish and at times annihilate the trunk, and the *ensemble* of which forms an enlarged and diffused head; such are, with about five or six exceptions, among the thirty individuals of which this lot is composed, the *pins sylvestres* of the High Alps.

"It may be seen from this that they are amongst the lowest rank of the species to which they belong, and that in the formation of pine woods they should be avoided. But this exclusion ought not to extend to all possible cases; there is one in which the Briançon pine may not only be useful, but better than all others of the species; it may be so where plantations are formed on the brows of mountains, or on their plateaux exposed to the violence of winds. The little disposition manifested by it to attain height, the thickness of its base, the strength of its lower branches, which are persistent for a length of years, almost carpeting the ground, make it more suitable than any other of the *pins sylvestres* to hold on and grow in such situations; also when one is re-clothing mountains with woods, the Briançon pine may be employed with great advantage conjointly with the *Mugho*—the former to garnish the middle region of the declivity, the *Mugho* for the higher zone—for these are the respective places which Nature has assigned them on the brows of mountains."

In writing of the fivefold series, which he had formed, M. Vilmorin says:

"These five divisions are not by any means equally good, or nearly so. The first and the last (the elongated pyramidal Riga pine and the pine of Briançon) present the only two types absolutely distinct; the others have characters much less decided. This could not be avoided, and pertains to the very nature of the species in which the individuals as well as the local masses differ—one may say indefinitely. And thus between the two opposite types which I have just named, the lots in the school form an unbroken chain, which binds together these two extremes. The sub-divisions, as I have said, were necessary, as may be seen indeed by the definition of the five series adopted.

"The outline, such as I have been able to give it, does not yet suffice for a convenient classification of all the lots. A certain num-

ber present intermediate characters, but too ill-defined to allow of them being taken as typical forms, and thus to increase the number of divisions; others have no characteristics of their own, but a mixture of many types, without a marked predominance of any. In these two cases I have placed these lots, under supplementary titles at the end of the series to which they most closely approached.

"In this mode of classification, the two extreme types, the elongated pyramidal Riga pine on the one part, and the Briançon on the other, are perfectly distinct; a third and intermediate type, the Haguenau pine, although less characteristic, is yet sufficiently so to allow of my admitting it as such."

The following are instructions given in the School of Forestry in regard to the exploitation of a forest of Scotch firs; but there are employed several terms not in general use in speaking of the management of woods and forests in England, of which it may be well to give some explanation. One of these terms is *revolution*. This is applied to the time occupied in the complete reproduction of a forest in the state in which it may be at any one time, as, for example, from the sowing, or from the felling of one crop to the sowing or felling of a second. Fellings executed at different periods of the growth of the trees, with a view to the effecting of different objects have different designations given to them. Amongst these are the following: *coupe d'ensemencement*, a designation given to a thinning of the seedlings or saplings, and of trees left to give shade to seed in germination, and to seedlings in the early stages of their growth; *coupe secondaire*, a designation given to a second thinning of the same kind executed seven years later; and *coupe definitive*, a designation given to a third felling of the same kind, when all trees of the previous crop left growing to supply shade and shelter to the rising crop are felled, leaving of that crop only such as are destined for the production of seed by which the ground may again be sown, to which standards the designation *Baliveaux Anglice*, staddles, is given.

There are other technical designations given to fellings or thinnings in other circumstances, with a view to the accomplishment of other objects; but with these we do not here come in contact. There are, however, other terms which it may be well to explain, such as *Bois blanc*, *Morts-bois*, and *Gualis*. The first designation is applied to wood of little value, such as that of willows and poplars, etc., the second is applied to worthless brush-wood, or undergrowth, junipers,

hazles, elders, cornels, etc.; the last, to perches and poles, from which the lower branches have fallen through want of nourishment.

To resume then our account of the instruction given in the School of Forestry at Nancy, in regard to the exploitation of a forest of Scotch fir.

"In countries in which this tree, *pinus sylvestris*, is very common, they do not allow it to become aged. In effect the annual increase of forest masses of this tree attains its maximum when it attains the age of 60, 70, or 80 years; then, after maintaining this for some 20 years, it begins to diminish with the advance of age. When then, the primary object is to procure firewood, it is best to fix the *revolution* cycle, or crop, at from 80 to 90 years. And this may be worth attending to in countries in which this is the perdominating tree; but even in such a case, parts of the forest should be submitted to a more protracted *revolution* to get useful timber of good quality.

"In France, where timber is more scarce than firewood, the State cannot fail to profit by delaying the exploitation of the pine. At the period of its maximum increase, its wood is not of the best quality. It is only at a later period of growth that the grain of the wood becomes compact, that it becomes charged with condensed resin, and thus acquires the elasticity and durability which makes it valuable in the construction of great works, and more especially for the navy. In view of such considerations, it would be well to apply to it a *revolution* of 120 years on lands on which its growth is active, and not to exploit it till it have attained the age of from 140 to 160 years in dry soil of sufficient depth, like the siliceous sands in which this tree delights, and acquires more especially the qualities which fit it for employment in great works.

"It must however, be remarked, that protracted revolutions have this inconvenience, they compromise the fertility of the soil. After a time, in the course of this protracted cycle, the pine forest no longer constitutes a close mass, and it comes at an advanced age to be converted into something like a glade. It follows that in course of time it becomes covered with hurtful undergrowth, the wind disperses the bed of dead leaves, and at the termination of the cycle the ground finds itself sodden, dry, impoverished, and in circumstances most favourable for the multiplication of very hurtful lepidopterous insects, the caterpillars of which only earth themselves in the driest soils.

"When then a cycle of 120 years or upwards is decided on, not only should all deciduous broad-leaved woods, which naturally come

up under the pines, be carefully preserved, but it may be well to introduce towards the middle of the cycle a subsidiary tree, designed to protect and to ameliorate the soil. The yoke elm, the beech, or the Norwegian pine, would prove well adapted for fulfilling this function. The last mentioned especially, placed in a second range, gives to the growth of the pine a magnificent upward growth.

"*Fellings preparatory for a succeeding crop.*—With a view to a natural resowing of the soil, it is not necessary that a deep shade be preserved, and, without disadvantage, the trees left standing may be so dispersed that the branches of them may be from 5 to 6 mètres distant.

"In selecting trees to be reserved, it is not the straightest and tallest which are to be preferred; it is more advantageous to reserve those which are of a medium height and branching; such are ordinarily more fertile in seed, and they better resist the winds. In the actual state of the forests in France there is as yet little room for choice; but it is expected that after a time, when the forests shall have felt the effect of regular management, there will be found not only on the outer skirt of the forest, but over the whole area, trees of a medium height loaded with branches.

"In spacing out the trees to be reserved, precautions must be taken against the havoc of the winds, and the invasion of herbs or hurtful plants. The pine sends down a tap-root, and otherwise roots itself firmly; but, nevertheless, on parts very much exposed to the wind, and where experience has proved that this tree with difficulty resists it, it may be well to leave a pretty dense reserve. The second inconvenience is frequent in pine forests, and on some grounds almost unavoidable. It may, however, be mitigated by not making the *coupe d'ensemencement*, or first felling, excepting when assured of an early and abundant fructification, which, in the case of the pines, is pretty frequent, and may be foreseen eighteen months in advance. Further, in the autumn or the winter preceding the scattering of the seed, it may be well to proceed to the extraction of the stumps, and to till the ground in rays, or in narrow furrows, at the bottom of which it may be stopped, and shall find a mobile fresh earth favourable to the germination of it and to the growth of the young plant.

"In the majority of cases these labours will not be unremunerative, for the stumps of pines, from the resin which can be extracted from them, are a more lucrative product than are those of other trees.

"After the *coupe d'ensemencement*, when the replenishing is complete, and the young plants have attained to near the height of from

16 to 24 centimètres, it may be proper to proceed to the *coupe definitive*. It may be imagined that the vigorous nature of the young plant renders unnecessary the *coupe secondaire*, and that it is necessary to hasten the withdrawal of the covering which is altogether contrary to its requirements.

"In despite of the prudential measures taken to re-produce a pine forest by self-sown seed, we are driven to acknowledge that it is extremely rare that we meet with complete and satisfactory replenishings in forests of this pine. To such an extent is this the case that many foresters are disposed to renounce *coupes d'ensemencement* in pine forests—to make a clean sweep, and to have recourse to artificial sowings, which succeed readily and well.

"In view of the general facts, it is necessary to say that this opinion is not without good foundation. Let the reserves from the *coupe d'ensemencement* be numerous or otherwise, let the *coupe definitive* be expedited or delayed, one often sees the best and most complete natural re-sowings come into jeopardy at the end of some years—diminish and disappear in places to such an extent as to give access to the *mort bois* and to the *bois blanc*. The cause of this it is rather difficult to ascertain. Some writers attribute it to insects, such as the worm of the Maybug, the *Pissode note*, and the *Hylobe*, which attack, the one the stems and the other the roots of the young pines. Mr. Berg thinks, with reason according to my judgment, that we must seek the cause or occasion of the evil in the superficial position of the roots of the old pines, the very abundant fibrous tufts of which cover and penetrate the soil in every way, and absorb thus in its entirety the nutritious moisture, being manifestly much more vigorous than the feeble rootlets of the young plants.

"Accepting this opinion, one is led to conclude that natural replenishings have no chance of success excepting in ground pretty wet and pretty deep, in which the pine, advancing in age, may extend its roots to a lower depth than the layer in which the young plants throw out theirs during the early years of their growth. But it is well known that pine forests occupy in general the less fertile soils, and thus we can account for natural replenishings being rarely satisfactory and complete.

"Were it not the important consideration of the expense of replenishing artificially through the purchase of seed, which is dear, and the expense of labour, and further, the risk run of not always procuring good seed when it is purchased, one would be led, from what

has been stated, to lay it down as a principle that the reproduction of this pine ought to be carried on by making a clean sweep of the trees, followed immediately by artificial sowing; and that *coupes d'ensemencement* ought only to be practised in exceptional circumstances, as, for example, on ground on a declivity. Forest science counsels the former mode of procedure; but financial considerations enforce most frequently the adoption of the latter."

M. Nanquette states in a note that the most important forests of the *pin sylvestre* were formerly subjected to the *mode à tire et aire.* Thus were they treated till 1820, when the system *des compartiments* was substituted for this, in so far as the principal fellings were concerned. In these fellings there were reserved a certain number of trees, with a view to securing a re-sowing of the ground, and in order to render more certain the natural reproduction. There is laid upon the purchaser the burden of pulling up bushes and mosses, and giving to the soil a slight tillage in alternate bands.

"Such is, in few words, the treatment formerly given to those forests in which we find to-day woods produced by self-sown seed perfectly complete, and of all ages anterior to 1840.

"The power of imposing works in connection with fellings having been suppressed, now well nigh forty years ago, they ceased to cultivate *le parterre* of *coupes d'ensemencement.* But soon they perceived that the fellings were not replenished, or were replenished badly—or at the least that they must wait too long a time before obtaining a sowing sufficiently complete, and at that time they adopted the plan of recovering them by artificial replenishings.

"The easy execution, and the so to speak assured success of this operation on the one hand, and the unsuccessful issue of *coupes d'ensemencement* on ground not prepared for them on the other hand, gradually gave rise to the conviction that it was for the general interest to substitute in a general way artificial for the natural replenishing. But they were not long in discovering that the new mode of replenishing gave no better results than that it had superseded, and, as it is much more costly, they returned quite naturally to the old practice of *coupes d'ensemencement*, and the preparation of the ground for these fellings.

"A very light tillage, a simple scraping of the moss which spreads over dry ground, the opening of strips or of furrows in the soil too strongly covered with herbage or bushes, suffices to ensure the natural replenishing of fellings with a little delay.

"The replenishings thus obtained are not generally so thick and so good as can be obtained by hand sowing; but they offer many important advantages which these do not: in point of fact, the young plants of the *pin sylvestre* are very robust, and grow with rapidity in their first youth if they be rather sparsely sown; their lower branches display themselves, the foot of the trunk becomes thick and strong, and by degrees the forest mass forms itself, and becomes so compact as to give a very complete replenishing before arriving at the state of *gaulis*.

"The natural sowings, probably because they are less dense, escape almost entirely the grave evil of defoliation which generally comes upon artificial sowings, and often retards their development during many years.

"Finally, in despite of the advantage which may be had from practising a great clearing amongst the saplings, the difficulty of carrying out this delicate operation on an extensive scale prevents recourse being had to it; and the artificial sowings, too thick at the first, do not present more when they arrive at the state of *gaulis* than long weak stems, and often they have not a future because the young pines are liable to bend or break under the weight of snow or of hoar frost, on account of their branches being spread and their leaves long, and also it may be from the snow often falling in large flakes, and in great quantities at a time in the climate inhabited by this tree; hence it may be concluded that they will stand only a very partial clearing. But this tree, after it has passed the stage of *gaulis*, sustains but badly a dense mass: branches which cross each other lose their leaves, and are not slow to perish; the head of the tree, instead of developing, becomes lanky, narrow, and, when this abnormal condition continues long, most of the tops become deformed, the trunks themselves contract diseases, and the whole mass becomes at times unfit to attain an advanced age or fine dimensions. To prevent this last and grave inconvenience, without at the same time exposing the young pine forest to being destroyed by the snow, the most certain method, the efficacy of which has been tested by experience, consists in executing the first thinning, contrary to the general theory, while the wood is still in the state of thicket at the time when the lowermost branches begin to dry, and in carrying this out unsparingly. In point of fact, it may come to pass in this way that the produce so abundant in the first youth of a pine forest, may find itself restricted or at least diminished; but this inconvenience will only be temporary, till the remaining stems, having

more room to extend their branches, in a short time give to the ground a thick cover, while, on the other hand, they form a fine conical head, such as ensures a good ultimate growth, and at the same time a stem more thick and short, and strong enough to bear up under the weight of the snow.

"The subsequent thinnings ought to succeed each other at moderate times apart, which will have effect of rendering them less productive; but in their entirety they will yield more, and exercise on the vegetation of the stems, destined to grow to the completion of the cycle, the salutary influence for which such thinnings are designed.

"The wood of the *pin sylvestre* is used both in building and in manufactures, as balks, beams, boards, planks, staves, shingles, etc. When it has attained its maturity it is considered as solid and as durable as that of the oak. In ship carpentry and wooden bridge building it is used as flooring; and it is almost the only tree of which masts are made. For this use it is obtained in France from the north of Europe. It is only in the higher regions of the principal mountain ranges, where the growth is slow, and the ligneous fibre very dense, that there is a hope of timber being produced of the degree of suppleness and elasticity required for masts. And attention is being given to the seeking out sheltered spots in these regions where the tree will be comparatively safe from snow-loads and hoar-frosts, with a view to the cultivation of forest masses destined to meet this important public requirement.*

"The firewood furnished by this tree is very superior to what is supplied by some others of the coniferae; and charcoal produced by it is in demand for forges.

"The *pin sylvestre* produces one portion of the pitch and tar made use of in the French navy.

"It is the stumps and roots which yield most of this, which is abstracted by subjecting them in furnaces to a slow and gradual distillation.

"The wood thus deprived of resinous matters is reduced to a charcoal which is used for various purposes. And there are in many countries very productive contract sales of the stumps of this tree, with the privilege to erect such furnaces.

* A valuable memoir on this subject by MM. Bravais and Martins appeared in the second volume of the *Annales Forestières*, 1843, pp. 369–561.

"In some localities marauders have a practice of cutting deeply notches in the trunk of the tree to remove some portions richly charged with resin which they recognise by a deep yellow colour, and by a strong odour which is exhaled. These portions cut into small pieces are very inflamable, and are sold in place of matches and fire quickeners. It is scarcely necessary to say that this practice is most prejudicial to the trees."

The authorities of the Forest School of Nancy give the following instructions relative to the *collection and preservation of the seeds:* "The collecting of the cones should take place from the month of November till that of March. When it is requisite to make great provision for sowings this should be done as soon as they have attained maturity; in other cases it is preferable not to collect them until after the cold, as the nearer this action approaches to the period of natural dispersion of the seed, with the greater facility is this extracted.

"The extraction of the seed may be effected either by solar or artificial heat, but the former is preferable, as thus are obtained seeds of a superior quality; but the latter is more generally employed, as it is more expeditious and better admits of making collections in great quantities."

Hartig, the father of Modern Forest Science in Germany, has given a description of the arrangements adopted in such cases, of which the following is a translation:

"There is used an apartment in the lower storey of a stone building. There are placed in such an apartment one or more stoves, fitted up with grates that they may be heated by the combustion of emptied cones; and there proceed from these stoves a circuit of pipes conveying heated air as in green-house, hot-house, or stove, that in every part the room may be heated to a sufficient temperature. In this hot-house there are constructed against the walls and in the centre scaffolding on which may be placed trays of wooden lattice work, or of wire work from 1 mètre 66 centimètres, to 2 mètres in length by 82 centimètres in breadth, in stages of about 16 centimètres between. Under the lowest range of trays are placed drawers to receive the seed.

"They then charge the trays with cones, and heat the stove to as high a temperature as a man conveniently can stand, (20° to 25° R.) 80° to 90° Fahr."; and Cotta, who followed Hartig, says that the

temperature may be raised to 30°=100° Fahr., or even 35°=112° Fahr., without injury to the germinative power of the seed. "This heat is maintained until the cones open, they are then stirred or shaken briskly in all the trays, commencing with the highest series, that the seeds may fall from tray to tray till they reach the drawers under the lowest tier. To facilitate this shaking of the trays, they have been made moveable on rollers in two grooves, so that, by pulling and pushing the tray, all the cones contained in it may be easily moved.

"When all the cones have opened as extensively as possible they are withdrawn, and the seeds still remaining in them are collected. For this purpose they are placed in a vessel like a churn, in which there is a suitable opening by which the seeds may pass and be received into a vessel placed beneath. The cones are thus briskly agitated until they are completely emptied of seeds, and the empty cones are employed to feed the fire.

"When solar heat is to be employed, the scaffolding is supported against the wall of a building on a southern exposure. On this the trays are disposed at such a height between that the sun's rays may fall on all, the highest and lowest alike. Under the lowest trays are drawers, provided with coverings of thick cloth, that if rain fall the seed may be easily covered and kept dry.

"The whole apparatus is covered with a light roof, the slope of which is towards the north.

"When there is a powerful sun and great heat the cones are shaken, commencing with the trays in the upper tiers, and proceeding in regular succession to those of the lowest row; and the seeds are then collected in the drawer. At last, when it is considered that the cones have opened as much as possible, they are taken away and put in a churn such as has been described for the extraction of those seeds which may remain in them."

MM. Parade, etc., say "that the apparatus employed in connection with solar heat has been practically perfected by attaching to each tray a moveable cover which is closed during the night, and when it rains, and can be opened to varying extents according to the heat of the sun. And that this cover may better reflect the sun's rays upon the cones, the lower surface is painted of a white colour or is varnished.

"To these houses constructed for the drying of seeds, the designation *Sécheries* is given in France.

"The Forest Administration of Forests in France has in the forest

of Haguenau (Bas-Rhin) an establishment of this kind, which annually supplies seeds of the pine which are shed in the forests of the state.

"When it is desired to divest the seeds of their wings, they moisten them, and after having put them into a sack, filling it only to the extent of one fourth, they rub it until the wings are detached. Then, after having spread them out in a well-aired place, to expedite their desiccation, they are cleaned completely by means of a winnowing fan.

"Moistening the seed may be avoided, which it is preferable to do, by spreading out the sacks filled, as has been described, on a thrashing floor, and thrashing with a flail to beat the seed.

"The divesting the seeds of wings is advantageous, as it facilitates transport by diminishing both bulk and weight; and further, seed so treated sows better, and runs less risk of being dispersed by the wind. But, in general, the seeds which have not been subjected to this operation, especially such as are obtained in commerce, keep better than those which have been so treated. In the establishments, more especially those of Germany, where they prepare immense quantities of seed for sale, they sometimes put the seed into a heap after having well moistened it, and leave it there until, on the insertion of the hand, there is felt a slight heat, and then the wing may be detached with the greatest ease. It may readily be seen that such a process pre-disposes the seed for germination; and if the sowing be delayed it may be found that there are a great many which have lost their power of germination.

"The seed of this pine designed to be sown may be preserved for three or four years; but when this is to be done it should not be divested of its wings. And it will be preserved still more certainly if it be left enclosed in the cones, and if these be not gathered till the end of winter.

"Seed of the *pinus sylvestris*, when of good quality, is firm and well filled; its smell on opening it is fresh and resinous. When crushed on the nail, the small kernel leaves there a greasy substance with an oleaginous smell. The seeds of the pine are black or white.

"A greater number of empty ones are to be found amongst the latter than amongst the others. It may therefore be well, in purchasing seed, if the white be in excess, to test them with the more care.

"Seed of the Scotch fir should weigh from 120 to 140 grammes per litre if winged; and from 440 to 500 grammes if divested of the wing."

In regard to the sowing of the seed, the following are the instructions given: "The seed may be sown on alternate bands, of from 66 centimètres to a mètre in breadth, or by placing a few seeds each in a shallow hole somewhat sheltered, but not much shelter is requisite. In southern slopes covered by heaths, on which the pine is often sown, it is necessary to adopt a particular precaution in preparing the soil, namely, to dig the bands or the holes to the layer of soil below the blank soil found on the surface, and which is generally designated heath soil [peat?] In sowing the seed on heath soil, which has no firmness, which is incapable of retaining moisture, and which, from its colour, absorbs heat in a high degree, the seeds almost always fail; and frequently the heath soil contains an acid principle which makes germination completely abortive.

"It is stated that this is acetic acid, and it has been proposed to neutralise it by employing *ecobuage*, or burning the turf, which, by the ashes which it produces, would accomplish this end. This operation may suffice to prepare for the culture of certain plants which require little moisture, and for the growth of such as return to the soil almost the whole of the mineral elements of their structure, in such a way as to mix with the layer of earth the mineralogical element of the soil. But for forest trees it would not be the same, for in abstracting from the ground one noxious principle, the ashes would add to the lightness of the soil already too great, and to its defective power of absorbing moisture from the air.

"The seeds ought not to be covered to a greater depth than from 4 to 6 millimètres; it may even suffice to mix them with the earth by means of a rake. Ordinarily the young plants appear at the end of from four to six weeks, when the sowing has taken place in spring, which is most advisable; but it also often happens when the seeds have been too deeply buried, or too much heated in the extraction, that they do not germinate till the second year.

"In some parts of Germany, where the seeds of the pine are very abundant, they are accustomed to sow simply the cones in the bands, or in the holes prepared for this purpose; then, as the heat of spring begins to act on the scales, they shake the cones roughly with a rake, to cause the seeds to fall out and to distribute them as equally as possible. This proceeding has first the advantage of saving the expense of extraction and divesting the seeds of wings; in the second place, the seeds are generally of the best quality; and the cones which cover the soil may give some protection to the sprouting plants. But, on the other hand, a portion of the seeds are lost, for they can never

succeed in getting all out from the cones; they are not so equally spread over the ground; and the cones are more cumbersome for transport.

"The quantity of seed to be employed for a partial sowing per hectare are:

Winged seeds, ...	12 to 14 kilogrammes.
Seeds divested of wings, ...	9 to 11 ,,
Cones, ...	18 to 20 hectolitres."

CHAPTER X.

Natural History and General Culture of the Maritime Pine in France.

Sect. I.—*Commendation bestowed on the Maritime Pine.*

The success which has followed the endeavours of M. Bremontier to arrest and utilise the dunes and sand-drifts of the *landes* of Gascony, by planting them with the *pinus maritima*, has led to the name of this pine being closely associated with thoughts of these *landes*, not only there, but in lands far remote, in which attention has been given to the subject.

The growth of the maritime pine in France is not confined to Gascony, but is carried out elsewhere as a temporary application of sylviculture to prepare the soil for agriculture, or for the introduction of trees better adapted to the climate, or to the wants of the inhabitants of the country adjacent, or more remote. In some of the districts in which this is done the trees do not attain so great an age and size as they do on the *landes* of the Gironde and adjacent dunes. This is the case on La Sologne, in the district of the Loire and the Cher, where they generally have to be felled after a growth of twenty years, at which age the trees may supply supports for telegraphic wires, and wood which may be applied to similar uses; but it is chiefly as firewood that the produce can command a sale, and in such districts special attention has been given to the conversion of these products into fuel.

M. Boitel says of the maritime pine: "The rapid growth of this evergreen tree has made it a favourite with foresters. What other tree becomes productive at seven or eight years of age, and even then exhibits a strength and beauty which completely changes the aspect of the country by changing desert ground into a forest!

"Add to these advantages that it thrives in light poor soil unfit for any other purpose, and we can easily comprehend how much it is prized.

"The forester of the *Landes* or of Sologne exhibits with pride heaths turned into forests by the labour of his hands. So a desert

inhabited by a few wretched sheep has succeeded an immense timber forest, supplying in abundance timber, firewood, and resinous substances.

"Many are the villages which owe their foundation to the introduction of the maritime pine, before which there was a dearth of timber and of firewood for baking the bricks and tiles, which are indispensable for building purposes in a country devoid of means of transport.

"I cannot enumerate here all the benefits to mankind rendered by this tree; let it suffice to briefly notice some of the chief uses of the tree.

"Immense sandy plains in Gascony, Orléanais, Touraine, and Maine have become profitable through its culture.

"Certain cantons, formerly desert and uninhabited, owe their improvement to the maritime pine, which furnishes materials indispensable for houses and workshops; its timber and resin are useful for domestic purposes; the baker needs firewood, the painter turpentine and varnish, and the sailor tar for ropes, timber and pitch for his vessels and boats; and by this tree all these are supplied.

"On the sea-shore the growth of the Bordeaux pine is the only means of arresting the invasion of the dunes, which, like an ocean of sand with moving waves, lays waste the fields and carries misery and desolation into important populous centres.

"Its protecting shelter from the caustic action of the salt winds permits cultivation to be carried on in spots where this would otherwise be impossible, and it withstands tempests better than any other tree.

"The maritime pine is met with all over France; in fertile ground where it would be the reverse of profitable, it occupies an important place in landscape gardening.

"To sum up, in cleared land it appears as the first symptom of civilisation and progress, and is connected with one of the most wonderful discoveries of the age, for with two of its relatives it shares the privilege of supporting the wires, which in a second convey human thought to the ends of the earth."

In another connection he writes thus on the same theme:

"The maritime pine is at home in Gascony, there it attains the largest size, and, provided that sheep are absent, it multiplies indefinitely when once introduced. Sologne does not suit it nearly so well, it suffers from the inclemency of the climate and the badness

of the soil. Without culture the pine would never have formed forests in that district, and it may be asserted that the plantation would soon disappear if they were not kept up artificially. This tree, which lives for a hundred years in the south of France, often in Sologne, reaches maturity at 25 or 30 years. This great difference naturally involves important modifications of its culture and exploitation.

"The inhabitant of the *Landes* who can count on the longevity of his pines, expects them to produce resin and timber, firewood being only a secondary consideration.

"The Solognese, on the contrary, knowing that his pines are rarely large enough for timber, or to be subjected to regular *gemmage*, values them chiefly as firewood, *Cotrets bourrées*, charcoal, and charcoal powder are the most important productions in Sologne. Only here and there do some woods situated in deep moist soil furnish trees fit for the carpenter.

"Of late years, quantities of telegraph poles are supplied by Sologne, for this purpose trees are required about the age of 20 or 25 years.

"Although wood that has not been tapped appears to last a shorter time under water, not long ago some of the finest trees in Sologne were selected to form piles as the basis of a new bridge lately built at Mayenne.

"I am led to conclude, from some recent experiments, that it would seem to be advantageous to tap the pines in Sologne, especially those which are to be felled.

"*Gemmage* should be practised in Sologne with prudence and circumspection. We must remember that the tree so far north generally lacks strength and vigour.

"Too great a *gemmage* practised on feeble, sickly trees would certainly shorten their lives, and a loss of timber would result, for which the resin obtained would not be compensation.

"Only trees on the point of being felled should be subjected to the process. As to others, they should be let alone to grow before it is attempted.

"So soon as the trees appear strong enough to support the operation they should be carefully operated on, only one incision made on each tree, and this incision a small one, this being essential to the health of the tree."

M. Samanos, in the introduction to his *Traité de la Culture du Pin Maritime*, says: "There has long been realised in the district of our

landes the importance of creating a plantation of the maritime pine; and yet, for all that, it may be said that but a few years separate us from the time when the *Landes* of Gascony, veritable French Savannahs, presented to the eye of the saddened traveller only a picture of desolation and of death. Far as his eye could reach he could see only heart-sickening monotony and gloom; and it seemed to him as if on this bare and naked land sterile Nature had cast her heavy curse.

"While the whole of France elsewhere expanded herself under the rays of progress, the *Landes* remained there—always uncultivated and unproductive—always immersed in their unmeasured sadness—giving shade in the brilliant picture of the fruitful conquests of civilisation, and presenting to all men the great and gruesome spectacle of a fatal neglect; for, as Viscount Izarn-Freissinet remarks, in his *Coup d'œil sur les Landes de Gascogne*—'*parce que tout y était à faire, rien n'y a été fait.*' Because everything in connection with it had to be done—nothing at all in connection with it has been done.

"Such neglect and such abandonment of the land could not last always. There came at length the day when societies were formed for the clearing and cultivation of these *landes*. But those who took the direction of the measures to be adopted were mainly imbued with notions essentially and exclusively agricultural. They wished to establish on a grand scale the culture of vegetables which the geological conditions of our sand-wastes could not support. They were foiled. Advancing with giant steps they landed themselves the more precipitately in ruin, and they were forced to stop, buried as they were under the weight of failure, so much the more overwhelming that it was unexpected.

"Behold then once more our *landes* abandoned and uncultivated and alone in their immensity; they seemed to be for the future doomed to everlasting sterility.

"But if there had been a want of success it was the fault of man, not of the *landes*. To change all that, it was only necessary to act more wisely. This has been done, and now it has come about that the four hundred thousand hectares of these desolate *landes* have become four hundred thousand hectares of young and vigorous forests. Almost everywhere the plough has produced its furrows, and the hand of man has stocked these savage deserts with maritime pines, which will become for the country a fruitful source of wealth, and supply some day the wants of the whole of France.

"Writings on the maritime pine were for a time quite the rage.

Societies being formed for the clearing and sowing of the *landes* it was needful to give instructions to the shareholders or capitalists of these companies, and show to them the great advantages which they might derive from this—to make palpable to them the supposition which might engage them to lay out on uncultivated and arid lands money, of which the interest would be invested on their hopeful promises—to remove from their minds the unwarranted prejudices which seemed to exist against our *landes*, and to prevent their receiving the attention they deserved; and it was necessary, in fine, for the success of the enterprises, that by descriptions, always exaggerated, our country should be shown to be another Louisiana, which should be exploited by another law. And this is what our economists have done. The question relating to the improvement of our *landes* was almost always treated of by men to whom a creative imagination supplemented the lowest modicum of knowledge in regard to the forest culture of our maritime pine; and these, seizing with itching hand the pen dipped in vapouring exaggerations, extolled the sterile plains which they described, and, by aid of subtile logic, they insinuated into the ideas of their readers ideas which had only for the greater part of the time absurd and incoherent foundations. With them our maritime pine was the veritable tree bearing apples of gold."

To expose the fallaciousness of these writings he cites some passages, for which, says he, common sense alone may supply pitiless refutations.

Delamarre thus writes (*Traité de la culture des pins à grandes dimensions;* page 306; third edition): "The culture of pines supplies the means of acquiring wealth. As the proprietor of uncultivated grounds, a hundred Parisian arpents for example (corresponding to thirty-four hectares) in extent, more or less unfit for every other crop, may, by a moderate advance of two or three thousand francs, and such attention as should be a work of pleasure, may flatter himself, not only to be reimbursed the outlay, capital, and interest in some ten, twelve, or fifteen years, but of obtaining from it from the first pretty considerable profits, and ultimately, in some fifty or sixty years from the commencement of the enterprise, a wealth to be reckoned by millions for himself, and perhaps as much for those whom, from the very nature of the undertaking, he will find he has associated with himself in the magnificent and honourable benefit which he has given; for even in localities in which the price of wood does not exceed twenty *sous* per cubic foot, his personal benefit should exceed fiftee n hundred thousand francs."

And again in the same work he writes, (page 289): "Thus one may say explicitly that in maritime pines the creator of woods is more than remunerated his advances, that he is even, in the benefits obtained during twelve years, reimbursed his first advances. I might even say that he is so within from eight to nine years; for, in the examples I have given, the net produce of the two first thinnings executed, the one at seven years and the other at eight years from the sowing, has been three hundred francs, while at this moment the advances, capital, and interest, have not come to this amount."

Such statements M. Samanos ridicules, and goes on to say: "J. L. Crinon, in his work bearing the title *le Forestier praticien*, (page 50) writes in these terms: 'I see amongst these, pines which would measure from ten to fourteen cubic decistères, and which have not been planted more than from forty-five to fifty years. These trees on an average scarcely occupy twenty-five *centiares* of ground. If we estimate their value at forty francs each—they cannot be less than this in value—and, reckon that there are to be found four hundred of them in a hectare, we shall find that a hectare planted in pines will avail for seventeen thousand francs worth of wood, after from fifty to sixty years! What is the kind of wood which offers like advantages to this?'"

"Evidently," says M. Samanos, "it has not an equal!" But he says it ironically, and goes on to say:

"I might go on to cite a host of opinions by many authors, such as Emile Béres, Baudrillard, Ballet-Petit, etc, all marked by numerous errors.

"'Although the value of these woods,' said, in 1826, M. Bilaudel to the shareholders, 'varies according as the situation is more or less near to the cultivated lands, still, and that according to calculations in which there is nothing taken for granted, there is not even in the actual state of things any speculation in agriculture more sure and more probable than this is.'"

All such statements M. Samanos condemns. I cite them as views which have been advanced, founded it may be upon isolated cases, but I cite them with the qualification of the critique by M. Samanos, whose treatise is valued highly by my correspondents in France.

Sect. II.—*General Culture and Exploitation of the Maritime Pine.*

The maritime pine, so exclusively cultured on the *landes* of the Gironde, is nearly allied to the Spardenny, or cluster pine (*Pinus*

pinaster), grown at the Cape of Good Hope, and they have several characterstics in common. By some these trees are considered varieties of one species.

Much valuable information in regard to the natural history and artificial culture of this tree is given in the volume just cited by M. Eloi Samanos, *Membre de la Société d'Agriculture des Landes.** But the treatment of the subject in that volume is complete in itself; and I deem it more expedient to refer the student to this in its entirety than to cite passages apart from the connection in which they occur; and I give here information I have gleaned from other sources.

The following is the information embodied in the "*Cours élémentaire de Culture de Bois*," at the School of Forestry at Nancy:

"*Le Pin Maritime*, the maritime pine *(Pinus maritima, Lamark)*, forms portions of considerable forests in the *Landes* in Provence, in Languedoc, and in Corsica.

"*Climate, Situation, and Exposure.*—Although this tree belongs more especially to warm climates, it is nevertheless cultivated successfully in the western Departments of France; but if it be exposed to frosts it does not live long, and the wood is worthless, its height and size are curtailed, and its usefulness is impaired. This is the case with sowings of it made at Fontainbleau, and in the suburbs or neighbourhood of Paris. There is no doubt that the maritime pine could not be acclimatised if planted farther north, as it is very sensitive to cold.

"In a suitable temperature it thrives on plains, on hills, or even on mountains of medium height. Its tap-root and lateral roots give it a strong hold of the ground, and enable it to resist storms which make it so much the more useful on the sea-shore, where it is planted extensively.

"*Soil.*—The maritime pine will grow on poor soil provided there be depth enough. It will even thrive very well on pure quartz sand, such as is brought down by rivers or heaped up on the sea-shore. Stiff and marshy soils are injurious to it.

"*Flower and Fruit.*—The blossom is monœceous. It flowers in March and April in the South of France, and in May in more temperate regions. The seed is larger than that of the Scotch fir, and is furnished with a wing proportionate to its size; it is ripe about the same time as that seed, and it also falls at the same season.

* *Traité de la Culture du Pin Maritime.*

"The fertility of this tree is extraordinary; it bears fruit almost every year, beginning at the age of twelve or fifteen, sometimes earlier; to ensure, however, the goodness of this, seed should always be collected from older trees.

"*Young Plants.*—The maritime pine is hardy from the first; and all prolonged shelter is hurtful. It is only on the burning *dunes* of Gascony, and in the warm exposures of the south of France, that shelter is needed for the first few years.

"*Foliage.*—Although the leaves of the maritime pine are very long they only cast a feeble shade. They fall in the third year like those of the Scotch fir.

"*Roots.*—This tree has a tap-root which buries itself deeply in the ground; it has besides creeping roots which all along their length throw out long tap-roots; this tendency, along with its rapid growth, makes it very suitable for binding the moving sand on the *Dunes.*

"*Growth and Length of Life.*—The maritime pine grows very rapidly and it attains a large size. In one district of the *Dunes* of Gascony, where the soil is deep and nutritious, several trees, from which the resin has not been extracted, are to be seen about from 27 to 30 mètres in height by about 2, 3, and 4 in circumference, at the height of one *mètre* above the ground. The size is well proportioned and the trees have a cylindrical form. They reach an age of 150, or 170, years without showing symptoms of decay. We may therefore believe that the maritime pine may reach an age of 200 in suitable soil.

"*Qualities and Uses.*—The wood of the maritime pine is considered inferior to that of the Scotch fir and many other resinous trees. But it is not the less made use of for various structures. In dock-yards it is made into props and stays to support vessels during the process of building. It is also sold for vine props and planks.

"The firewood and charcoal of this pine are of indifferent quality.

"We may, however, be deceived regarding the value of the maritime pine. In order to the formation of an authoritative judgment, it ought above all things to be grown in suitable conditions of soil and climate, and to be treated according to the best methods of exploitation, besides which, it should be protected from pruning and the extraction of resin.

"Now, in the department of the Gironde and of the *landes*, this extraction, called *gemmage*, and *gemmer*, has been carried on on the Dunes for several centuries; and in districts elsewhere called *landes*, where the soil is usually poor and *gemmage* unfrequent, the maritime pine is exploited when very young, either for joiners' work, or for trel-

licing vines. In both these cases it is therefore impossible to know accurately the qualities of this tree.

"The process employed in order to extract the resinous juice of this tree will give an idea of the injury thus inflicted. *Gemmage* is usually begun when the tree is twenty-five years old, and goes on from April till September. The first thing is to remove a strip of bark from 12 to 16 centimètres in breadth, extending from the foot of the tree to a height of from 33 to 50 centimètres. The incision is deep enough to cut through the alburnum, for the resinous juice issues chiefly from the ligneous trunk, and from between the bark and the wood. Every week the wound is re-opened. These incisions in following years are carried upward to a height of from 4 to 5 mètres. A new incision at the root of the same tree is then begun. It is parallel to the first, from which it is separated only by a width of from 5 to 6 centimètres; it, as well as later incisions, extends to the same height. These incisions are carried all round the tree, and are called *quarres.*

"This method of *gemmage* is the most gentle; it is called *gemmage à vie.* When it is wished to go to greater lengths two incisions are made simultaneously, one at the top the other at the foot, the first is called *quarre haute,* the second *basson.* Sometimes incisions are made all round the tree at the same time. This operation is called *gemmer à mort,* or *à pin perdu.* Up to the present time the maritime pine is chiefly cultivated for its resinous juice, which furnishes articles of undoubted value, consisting of turpentine, pitch, tar, and lamp-black. As a source of revenue there is no doubt that the present mode of exploitation is the most profitable, and is therefore quite justifiable. But in the departments of Gironde and the Landes they go further, and assert that the maritime pine, if it is to be of any use at all, ought to be *resiné.* It is even affirmed, despite of examples quoted to the contrary, that the extraction of the resin is indispensable for its prosperity and even its existence.

"We may easily see that *gemmage* must interfere injuriously with the growth of the tree. Nature has not given it a resinous juice for nothing, and this juice, independent of the sap, seems, in combination with the latter, to promote nutrition and growth. As a proof of this, when pines which have been *gemmé* are felled, they exhibit very narrow annual layers, which bear witness to a retarded growth, whilst the opposite has been seen in pines which, without having been *gemmé,* have grown in precisely similar conditions; but it has been ascertained that the timber of resinous trees is more solid, and has

more resisting power, in proportion as the layers are close and compact. Further, *gemmage* promotes an active current of turpentine from the centre to the circumference, which leaves a considerable quantity of concrete resin behind in the wood tissues which it has traversed. It can thus be understood that *gemmage*, by retarding the growth, imparts at the same time to the wood qualities which it would only in a state of nature have acquired at a much greater age."

In regard to *semis*, or sowings of the maritime pine, it is stated generally that these have to be conducted in every respect as are sowings of the *pinus sylvestris*, or Scotch fir; and the following details are given in regard to the *pinus maritima:*

"*Examination of the Seed.*—The seed of this pine is much larger than that of the Scotch fir; it is grey or brown upon one side, and shining black on the other; otherwise it possesses the same characteristics as the seed of the Scotch fir.

"*Putting in the Seed.*—All the various methods of cultivation with which we are acquainted are applicable to the maritime pine. The plough is usually employed for preparing the earth, and the harrow for covering the seed; the seed being larger requires to be covered with a greater depth of earth.

"The quantity of seed employed per hectare varies much. In Sologne, for example (as reported by M. A. Brongniart), for a full sowing, about 10 to 20 kilogrammes are used. The difference is owing doubtless to the quality of the seed, or it may be according as the trees are to be close together, or the reverse. We think that from·15 to 18 kilogrammes of seed with the wings on, and 12 to 14 kilogrammes of seed with the wings off, will be enough, bearing in mind that the seed of the maritime pine is usually of very good quality. For partial sowings these quantities should be diminished by one third.

"The maritime pine has been cultivated much more extensively lately in several districts in the west and centre of France on account of the peculiar products of this tree. But it is more especially in the Landes and in the La Gironde that it is of chief importance. It is well known that in these departments along the sea-shore from the mouth of the Gironde to that of the Adour, there extends a district called the Dunes of the Gulf of Gascony, which occupies an area of about 240 kilomètres in length, by an average breadth of 5 kilomètres. The soil of this district, composed exclusively of a very fine quartzose sand deposited on the strand by the waves, becomes so light when

dry that the winds carry it to a great distance. The smallest obstacle, such as a little hillock of soil, a tree, some tufts of broom, or of bent grass *(arundo arenaria)* are enough to stop the sand; it then accumulates much faster and forms larger heaps than when deposited by the waves, as the winds blow for a long time in the same direction. Such is the origin of the *Dunes*, of which the height and form vary like the conditions which have created them. Some are to be found from 20 to 30 and even 50 or 100 mètres in height.

"It is by a mixed system of wicker-work barriers and *reboisement* with maritime pines that the inroads of the sand which threatened the neighbouring communes have been nearly everywhere arrested; and it is one of the triumphs of the *Corps des Ponts et Chaussées*, to whom the Government entrusted this great and important work, and who have not only completed the undertaking, but they have by degrees improved and simplified the work and operations required, and have thus brought it within the power of any one to carry on similar work elsewhere."

To render intelligible to those who are unacquainted with the more advanced system of forest management followed on the Continent of Europe, the additional statements to be made, it may be well for me to state, that it differs considerably from the arboriculture which is generally practised in Britain, and from the *Jardinage*, and *Sartage*, practised in British Colonies and in the United States of America, and to supply here the following information in regard to it; and to repeat in substance what I have already said in speaking of the culture of the Scotch fir:

In the general management of forests on the Continent, in accordance with the most advanced forest science, three things are aimed at, and so far as practicable each is sought to be attained without detriment to either of the others: the sustained production, natural reproduction, and progressive amelioration of the forest. In prosecution of this there is determined, according as quantity, quality, or pecuniary profit may be mainly sought, at what age the trees shall mostly be felled. This in French is spoken of as the exploitability of the woods. But before this age is attained there are several successive thinnings executed, each with a special object, in accordance with which it has a specific designation.

The wood being the product of natural reproduction, or self-sown seed, there is often required a thinning out of the seedlings. This is known as the *coupe d'ensemencement.*

There may be required one or more successive thinnings as the

growth of the tree advances. These are known as *coupes d'amelioration.* There are subsequently thinnings executed to leave sufficient ground cleared and open for the reception of seed cast from the trees left standing. These are designated *coupes de régénération.* After which follows the final felling, or *coup définitive*, in which only trees required to give shade to the young seedlings, etc., are left standing. But there are exceptional cases, in which artificial sowing is deemed preferable. In these cases *coupes de régénération* are not necessary, and the *coupe définitive* takes the form of a clean sweep, known in technical phrase as *la coupe à blanc étoc.*

In regard to the treatment of the maritime pine, the instructions given at Nancy are in several points founded on those given in regard to the exploitation of the Scotch fir.

In these instructions we meet with the two terms *coupes de régénération* and *coupe d'amelioration*, in addition to the similar designations formerly explained. The former of these designations is applied to all the fellings or thinnings to which the forest may be subjected in the course of its reproduction; and the latter is applied to fellings or thinnings carried out with a view to the improvement of the forest in any way.

The corresponding instructions given in regard to the treatment of the maritime pine are these :

"*Exploitability.*—To ascertain what size this tree may attain, and at what period its exploitability should be fixed, it must first be cultivated without any injury being done to its growth, for until we gain light from experience we can only judge by analogy.

"Trees which grow rapidly when young generally attain their maximum development sooner than do others. This is particularly true of the maritime pine. Nevertheless, in the south, where the climate is favourable, it continues to increase in size for a long time, and on this account it ought not to be *exploited* for 100 or 120 years, according to the nature of the soil, that the timber may acquire the desired solidity for building and other purposes.

"Of course, in adopting this revolution, *gemmage* is not permissible.

"*Coupes de régénération.*—The maritime pine never having as yet been subjected to systematic culture, the method to be followed is uncertain. But from the nature of the seed, the constitution of the young plant, and the arrangement of the roots, we may conclude that it ought to be *exploited* in the same way as the Scotch fir. At the same time, at the *coupe d'ensemencement* there may be left fewer plants as this pine is better able to resist the wind. Indeed, the seed is a

little larger and heavier than that of the Scotch fir, but the membraneous wing is also larger, which favours its dispersion to a distance. The secondary *coupe* will be unnecessary, on account of the hardy constitution of the young plant and the extreme rapidity of its growth, which lead us to believe that the *coupe définitive* should follow the *coupe d'ensemencement* as soon as possible, that is to say, in the year after the *repeuplement*, or within two years at the latest.

"*Coupes d'amelioration.*—What we have said on this head regarding the Scotch fir, equally applies to the maritime pine. The first thinning should be expedited on account of the rapidity of its growth, and the intervals between those which follow should be abridged.

"The rules we have laid down for the *exploitation* are only applicable when the trees are not subjected to *gemmage*. When trees are to be *gemmé* these rules should be modified. For, on the one hand this operation diminishes the growth and shortens the life of the tree, and on the other it is not timber, but resin which becomes the chief product of the forest. The first circumstance renders much shorter revolutions necessary; the other, that the thinnings should be made at very short intervals, according to a method practised in the south of France, of which an account has been given.

"It being evidently the interest of the proprietor to hasten the period of *gemmage* as much as possible, it is of great consequence to promote the growth of the stem and summit in every way. For this end the young trees are thinned for the first time, at the age of seven, and afterwards the operation is repeated every six years until they are twenty-five years old, at which age they are supposed to have attained a suitable size. In these operations the pines are isolated by degrees. After the two first fellings the *mass*, although thinned, should still be preserved so as to promote the development of height; but after the third the number of trunks is reduced to 700 or 800 per hectare; and after the fourth only 500 remain; five years later these are again reduced to 400. The 100 trees doomed to fall in the fifth thinning are *gemmés à mort*, between the fourth and that, the others are *gemmés à vie*.

"These 400 pines remain standing from thirty to sixty years, and are *gemmés* every five years. At the expiry of sixty years, 100 trees are marked to be *gemmés à mort*, and are then cut down, while the 300 still remaining stand until the final *coupe* at the end of seventy or eighty years, sometimes of one hundred years, according to the state of the timber and the quality of the soil.

"We have already described how *coupes de régénération* should be

made. But it is believed that usually *la coupe à blanc étoc*, followed by artificial sowing, will be preferred. Indeed, in both systems the plough is indispensable, for, on account of the great distance between the pines, the ground cannot fail to be covered with all sorts of bushes and weeds ; besides, the seed of the maritime pine costs very little and is easily gathered and winnowed, the quality is almost always good, and the sowings succeed well ; everything tends to make the artificial way the preferable."

Both in the treatise by M. Eloi Samanos,* and in that by M. Amédé Boitel,† are given details in regard to the culture and exploitation of the maritime pine in Gascony, and in regard to the general culture of it elsewhere, additional to what has been given in this volume, inclusive of what relates to the *gemmage* or collection of the resinous sap, and the distillation and manufacture of the different products yielded by it.

* *Traité de la Culture du Pin Maritime.*

† *Mise en valeur des Terres Pauvres par le Pin Maritime.*

CHAPTER XI.

Diseases and Injurious Influences to which the Maritime Pine is Subject.

Sect. I.—*Choking by an Over-growth of Local Vegetation.*

Besides failures in the culture of the maritime pine, attributable to bad seed, and to unsuitable soil, it often succumbs to other injurious influences, which operate, not always singly and alone, but in combination, and one preparing the way for another. It suffers from cold, from hail, from snow, and from wind. When the tap-root comes upon a subterranean sheet of water, a layer of compact clay, or rocks somewhat coherent and continuous, it becomes covered with mosses and lichens, and it languishes, and dies; and yet subterranean aridity is not less opposed to its healthy growth.

In Sologne, where the natural shrubs are destructive to young seedlings, the precaution is taken of sowing the seed on newly cleared land; and recourse is had to some of the usages of husbandry, and the growth of annual crops, effective in themselves or their culture in cleaning the land, to destroy the noxious plants which might defile the ground to be converted into *pineries*.

M. Vilmorin has recorded that in his experience the couch grass, and some other of the grasses, such as the *agrostis stolonifera*, marsh bent grass, the *holcus mollis*, creeping soft grass, the *agrostis vulgaris*, fine bent grass, and many species of *festuca*, or fesque grass, may so take possession of the ground as to prove destructive to the young produce of sowings of pine trees; and in Sologne the growth of *bromus*, or brome grass, starves and kills the seedlings of the maritime pine, while in Gascony the broom is sown with this pine to shelter and protect it in infancy against the sunshine and the sea breezes; but there the seedling pines are stifled by a vigorous growth of heaths, such as the *erica cinerea*, the fine leaved heath, and *calluna vulgaris*, the ling or heather of Scotland.

Sect. II.—*Destructive ravages by Birds, and Squirrels, and Insects.*

Many birds, remarks Boitel, are destructive or injurious by eat-

ing up seed not completely covered; and the squirrels which abound in pine woods gnaw the cones and destroy the seed while it is yet on the tree. But these do also still greater damage, by eating away the bark near the sprout, whereby not only is the growth arrested, but the stem enfeebled at this point is often broken across by the wind. But, contrary to what occurs in Sologne and some other districts in which the tree is of feeble growth, and the ravages of the squirrel are most detrimental, in some places on the coast, where the growth is luxuriant, the finest trees are found on places where the squirrel abounds. This is attributed to their destroying the cones which are so abundant as to enfeeble trees by their production, and these being destroyed, the vigour, which otherwise might have gone out in provision for reproduction, is directed to the self-development of the tree. Sheep also are destructive to young seedlings, by browsing on the sprout and the more tender buds; this is the work of a few seconds, but the seedling, deprived of the sprout on the main shoot, remains ever after irregular in its growth, stunted and bushy.

But the most destructive effects are found to be connected with the appearance of certain insects on the trees. It is open to question, however, whether these insects be the cause or the effect of the evil done, or whether, as I think not unlikely, judging from what I have seen in similar cases, with other insects and other trees, their increase be not a result of disease, and the cause or occasion of death. Under the ravages of insects sometimes whole forests suffer, and the entire destruction of all the woods in a province seems imminent, while man is powerless to arrest the evil; and the maritime pine, like other trees, is subject to such damage.

M. Perris, of Mont-de-Marsan, in the *Landes*, an eminent French entomologist, who for years found occupation in observing the habits and transformations of insects which there prey upon this tree, so early as 1864 had recorded in the *Annales de la Société entomologique* of France, that upwards of 120 species of insects live upon it parasitically.

Certain of these insects attack the leaves or the terminal buds of shoots, and so produce physiological effects, which enfeeble the tree, and induce a state of disease. Amongst these are the caterpillars of the *Bombyx pityocampa*, of the *Tortrix buoliana*, and of the *Hylurgus piniperda*. Others attack the wood, and betake themselves to the wood and the bark. Amongst these are the *Tomicus stenographus*, *laricis* and *bidens*, the *Melanophila tarda*, and the *Pissodes notatus*. It is alleged to be indisputable that the former class attack trees in a

state of health; it is in regard to some, if not all, of the latter class alone, that there is any question.

"Authors," says M. Perris,* "seem generally disposed to admit that insects, the larvae of which are developed in the trees, while they are yet growing, are the primary cause of the death of these. There has thus been attributed to the *Pissodes notatus* the loss of an immense quantity of pines, which covered, in 1835, 190 hectares of the forest of Rouvray.

"The Marquis of Chambray, in his beautiful work on the resinous trees, speaks of an insect of the *genus* Bostriche, which, when it increases in great quantities, can destroy entire forests of the maritime pine. We read in the *Histoire de l'administration en France*, par Anthelme Costaz, t. I., p. 248, that in the seventeenth and eighteenth centuries the pine forests of Germany were so ravaged by the scolyte that the Hanoverian province of the Hartz feared a total loss of fuel, and was delivered from the fear mainly by the effects of several cold and wet winters, which caused the insects to perish in great numbers.

"As for myself," says he, "I cannot admit that these insects are the primary cause of the death of the trees which they attack, and in fifteen years, during which I have, without intermission, studied their habits in one of the best wooded countries in France, I have observed a sufficiency of facts to justify me in expressing my opinion, which is, that insects in general (not including those which attach themselves solely to the foliage, as miners, etc.) do not attack those trees which are in good health, but they only address themselves to those whose health and functions have suffered, from some cause or other;" and he subsequently expresses it as his painful conviction, that lignivorous insects are only to be dreaded by sickly trees. They are like some mosses and lichens which only attach themselves to enfeebled trees, while healthy, well-growing trees, preserve a smooth bark, and repulse these vegetable parasites.

"In the department of the Landes," says he, "where we reckon the pine trees by millions, I have never witnessed, and tradition has not preserved the recollection of a single case of these forest *razzias* which have afflicted other countries. Now the pine is exposed to a crowd of enemies, and the number of individuals of the most injurious of these is incalculable, and yet it is but seldom the case that one of those trees perishes, and I have still to find one which has been actually killed

* Annal Soc. Ent. France, 2mo Series, X, 513.

by insects. This comes about, according to my views, from this: the maritime pine being there in its true home, it there developes itself with vigour, then lives in good health, and thus braves the innumerable enemies which surround it.

"But let the pines become sickly through the effect of a hail storm, or of an insect having destroyed the leaves or the bud, and when, in consequence of the sickliness affecting the roots and spreading itself from one to another, this may invade the whole forest, if by a circular ditch the contagion be not arrested, then those lignivorous insects, divining the morbid condition of these sick trees, even while no external indication betrays the existence of the evil, throw themselves in mass upon their victims, and finish them off in a few weeks. . . .

"The insects most destructive to the maritime pine," writes M. Perris, "are first the *Bombyx pytiocampa*, the caterpillar of which devours the leaves of this tree, and may, if it multiply beyond measure, occasion such physiological derangements that there may result a disease, the consequence of which, through the ravages of the *xylophages*, or woodeaters, shall be fatal; second, the *tomicus stenographus*, *laricis* and *bidens*, the *melanophila tarda*, and the *pissodes notatus*, which destroy with great rapidity every so diseased tree.

"There has been recommended, as precautionary measures against these last mentioned insects, the destruction of all dead woods, the removal of stumps, the working up, or at least the removal of the bark of all felled trees, the placing in different parts of the forests attractive trees to allure the matured insects to lay their eggs there, and then destroying the larvae; but how can it be effected that these measures shall be carried out simultaneously, that is to say, by everybody at the same time, throughout the whole extent of a department, with many conterminous departments? Moreover, would the results be very appreciable, when there are in the higher and almost inaccessible parts of trees so many dead or diseased branches? And, furthermore, in practice it is impossible to carry out a really successful raid upon the insects; and this is indisputable with those who are acquainted with the management and exploitation of our forests, with the inadequacy of our agricultural population, and the indifference which, born of abundance and security, ignores all proceedings which involve trouble.

"With regard to the *chenille processionaire*, the local name given to the larvae of the *Bombyx*, which passes the winter in numerous communities in large nets of silk attached to the branches, it may be

said that it might be easy to master it. The legislative arrangements, which relate to the destruction of other larvae, might with all propriety be extended to this; and as there are four months during which the work might be carried on, there appears to be no reason why it might not be effected. But, it is well it should be known that the greater proportion of the nests are situated on the extremities of the upper branches of high trees, where it would be almost always impossible to reach them, and always dangerous to make an attempt to do so; it must also be told, that in order to get these nests it is necessary to cut down the branches which bear them, and that if each branch have one of them, as may be seen, it would be as well to fell the tree at once, as to subject it to the deadly operation of cutting off all its branches.

"We are then obliged to let things take their course, and to leave it to the birds, to the numerous parasites, and to meteorological phenomena, to bring, and to maintain within proper limits, the multiplication of devastating insects.

"There have been some years in which the vast forests of pines, in the department of the Landes, have been invaded by the *chenille processionaire* in numbers so prodigious that every branch and almost every twig had its nest of these. Before winter a great portion of the leaves had been devoured, and in spring the larvae coming out of their winter's torpor, finished by browsing on the rest; so that in the month of March one might have said that a fire had swept over the whole.

"These ravages, which nothing could be done to prevent, were continued two years, and caused many trees to perish. The people were in a state of excitement; and for my own part I did not hesitate to declare that if this went on for two or three years longer, this would probably be the case with the greatest number of our pines, the enfeebled condition of which would be followed by organic derangements sufficiently grave to attract the *bostriches*, the *buprestes*, the innumerable lignivorous insects always ready to throw themselves upon diseased trees, and the attacks of which are a signal of death.

"So, as I have said, this condition of things continued two years. In the third year, what was our astonishment to see that there was scarcely a nest upon the trees! The *Chenilles* had, so to speak, disappeared. The titmice, the magpies, the cuckoos, and other birds had doubtless destroyed great numbers, and doubtless some millions had become the prey of carniverous and parasitic insects; but, in

reckoning up all the partial destructions of them, we would be far from accounting for what had happened : some general plague must have fallen upon this innumerable race of devastators, and the following is my conjecture :

" In the month of May the *Chenilles processionaires* bury themselves in the ground, there to be transformed into the chrysalis state ; but they bury themselves at but little depth, in order that the butterfly may experience no great difficulty in taking its flight. The process of organic metamorphosis which takes place in the chrysalis, requires, as is known, that the insects be protected against too great aridity ; now the months of May and June in that year were remarkable for very intense heat and unbroken drought ; the sandy soil of the pine woods became desiccated to a great depth ; it was broiling hot, and the chrysalises, being unable to develope in that medium, became almost all abortive. Birth was given to few butterflies ; and thence it followed there were few *chenilles.* Two circumstances appear to me to justify fully this explanation : these are, first, in woods which were somewhat colder than others, and on margins adjacent to moist places, in the following year there were found nests in pretty great numbers ; second, since then, two other years, 1848 and 1849, have been marked by an aridity which was, so to speak, exceptional ; and one result of this was, in the winter 1849–1850, great distances might be traversed without finding a single nest. In 1851 they ceased to be so rare, and I remember I prognosticated that this would be the case, in consequence of some rains which fell in June and July, 1850.

" Thus a drought has sufficed to put an end to disquieting devastations, against which man had no remedy, and to-day (1851), the number of *chenilles processionaires* is reduced to one of no great magnitude ; they are, moreover, surrounded by so many enemies that they have for a long time ceased to be redoubtable.

" Apart from drought or other meteorological accident, the *chenilles processionaires* might have found, as has happened with other species, in their excessive multiplication itself the cause of ruin and mortality. The number might have been so great that food would have failed them before their complete development, and then they would have perished of hunger before transformation."

Such were the views advanced by M. Perris, Vice-President of the *Société d'Agriculture des Landes,* and distinguished as an entomologist who had given special attention to the insects living on the maritime pine.

According to the views of M. Perris, in the destruction of many of the trees, they were enfeebled by the destruction of leaves and leaf-buds; they were thus brought into an abnormal condition, and then, having become food attractive to lignivorous insects, they died in consequence of their ravages. And when other means than the primary ravages of the leaf devouring insects produce like effects to those thus produced by them, like consequences may follow.

Sect. III.—*Destructive Consequences following the Effects of Charcoal Burning.*

Professor Bagneris remarks in regard to a disease to be found in certain plantations:

"Frequently a pine is seen to wither and die, and the disease then seems to spread in a circular form, the diameter of which gradually increases. I have not been able to find out the cause. In Sologne origins more or less imaginary were assigned to this. May not this disease be caused by a fungus attacking the woody tissue? The form it assumes would lead one to suppose so, and the curative means employed strengthens the belief. In the Landes, a trench of 0·70 mètres in depth is dug all round the place attacked, and the circle of disease spreads no farther."

The following observations throw additional light upon the phenomenon, and seem to reveal the origin of the evil; if they do not determine also the question raised as to the possibility of a fungoid growth contributing towards the destructive result:

"In the district of Orleans", says M. Boitel, "the maritime pine does not present that vigorous production which in the south it owes to a soil and a climate which are particularly favourable to it. The sands of the Sologne are often deficient in depth, and when thence it comes to pass that the tap-root of the maritime pine comes upon a bed of tenacious and impermeable clay, the tree begins to languish, and its trunk and branches become covered with mosses and lichens. A good many pine woods find themselves in this condition when only fifteen years old. The trees stand out against the evil till they reach the age of twenty or five and twenty years; but beyond that they become stationary, and if they do not necessitate exploitation they are liable to be invaded and destroyed by insects which become developed in innumerable swarms in the bark and the wood.

"It has often fallen to my lot to ascertain and verify ravages thus

committed in the pineries of the Sologne, and more especially in the imperial domains, the forests of which have been under my direction for some time. In the Grillaire, an imperial domain in the vicinity of Motte-Beuvron, the lignivorous insects have carried out their ravages in the middle of an immense forest of pines from twenty to twenty-five years of age. The ravages had taken place simultaneously on a great number of points which served as centres to lacunes in the forest, the extent of which went on augmenting year by year in circular zones concentric with the primal circle; and in the radii of these concentric circles the trees were more diseased in proportion to their proximity to the centre.

"At the centre the trees had fallen and strewed the ground with heaps of their debris; farther away they remained standing, but dried up in all their parts; finally, at the extreme points of the circumference the leaves and the buds were beginning to get yellow, which announced the invasion of the insects; and the presence of these it was not difficult to ascertain otherwise, on examining between the wood and the bark, where the wood was literally ploughed up by numerous galleries which the myriads of lignivorous insects had dug and inhabited. In the middle of these gaps, where not a maritime pine was left standing, there were to be seen here and there some Scotch firs, *pinus sylvestris*, which, respected by the insects, manifested an astonishing vigour alongside of the languishing condition of the maritime pine.

"This fact," says he, "corroborates the opinion of M. Perris, who does not admit that lignivorous insects attack the trees in a healthy state. I accept willingly this opinion, supported besides, as it is, by numerous observations conscientiously made; and I think, with the distinguished entomologist of Mont-de-Marsan, that the pineries of La Sologne would be spared by these insects if the pines found themselves in circumstances more favourable to their development.

"In the Grillaire the circular lacunes ravaged by the insects present often an area of several hectares. The entire forest would have disappeared under the destructive action of these parasites if measures had not been taken to exploit them at once, and to forward the produce to Paris.

"It is noteworthy that there is found generally in the centre of each lacune charcoal debris, which marks the site of an old charcoal furnace. The pine is very sensible to the effects of fire and of smoke. In the forest of Villette (Loiret) the maritime pines are dead, from

having been exposed to the smoke of a brick kiln, from which they were distant about 50 mètres.

"Invariably, when there is established a charcoal kiln in the middle of a pinery, there are seen many circular ranges of pines, which, through the effect of the fire and of the smoke, become diseased, and they are not slow to dry up and perish.

"These diseased and languishing pines become the cradle of lignivorous insects which invade the forest throughout its extent, if after having completed the work of destruction on the first trees in which they were developed, they find themselves in the middle of a miserable pinery, covered with mosses and lichens, the diseased condition of which is so favourable to the propagation of these parasites.

"Sometimes, however, the ravages of the lignivorous insects manifest themselves notwithstanding that there are no charcoal furnaces there, or these are far distant. In these exceptional cases, in Sologne, the primary cause of the disease of the pineries can be attributed only to the humidity or to the unfavourable nature of the soil.

"After the enfeebling influence which reduces the trees to an impoverished condition, comes that of the vegetable parasites, which carry on farther the enfeebling of the trees; then come the insects which seize possession of a prey incapable of offering any resistance. According to some observations which I have made, it seems to me that the lignivorous insects occasionally allow themselves to precede those which betake themselves to the leaves, and buds, and young shoots. If this be the case, one may be struck with the harmony which ranges among the causes which tend to destroy a vegetable from the time that it is in other than the normal conditions of development. First, the soil produces its effect, then follow the parasitic vegetables, and then the lignivorous insects, which, in arresting the circulation of the sap, bring the final *coup* to the vegetable attacked in its every part.

"There come into operation in Sologne yet other causes to favour the invasion of the pineries by insects at the periods of the first thinnings. Great negligence is manifested in the operations carried on with a view to giving to the pine the air and light favourable to its development.

"Pines growing too densely in their infancy famish one another, the more vigorous destroy the more feeble, which become thus the food of the insects; at a later period, in the expectation that the expense of the thinning will be covered by the faggots obtained, or by the

manufacture of charcoal, there are carried on simultaneously and vigorously thinning and pruning, which give to the pine in superabundance the air and the light of which up to that time it had been deprived. Is it astonishing that trees so ill-treated and mis-managed should experience a physiological disturbance which renders them diseased and accessible to the numerous insects, which, after having multiplied in the faggot, the cords of charcoal, and the twigs with which the ground remains strewed, find later on subjects perfectly prepared to receive them!

"In all the circumstances of the case, the proprietors would find it for their interest in every way to secure to the trees that vigour and that health which defends them so well against the attacks of insects. They would ensure thus the duration of their pineries, and not expose them to premature decimation, which compels them to exploit them at an age at which it would be advantageous to maintain their conservation.

"Independently of these indirect evils occasioned to proprietors by insects, it is necessary to reckon also amongst the damages done by them those dead trees which rot upon the place, which can no longer serve for the making of charcoal, and it would be reckoned fraud to introduce that dead wood in the making up of the faggots, which, to possess the combustible qualities sought for by bakers, should be composed exclusively of living wood."

He goes on to say: "The forester has an interest in making himself well acquainted with the parasitic insects most hurtful to the pine, and in appreciating correctly the ravages committed by them, and the causes which tend to augment or to diminish these. The study of these will show to him that it is useful to give to the pines those periodical attentions which will ensure their vigour and successful growth; and as soon as a devastating insect may appear on his pinery, he will know what redoubtable enemy he will have to combat, and what are the urgent measures imposed upon him with a view to the restriction and diminution of damages very prejudicial to his interests." And he speaks in high terms of the work by M. Perris as supplying requisite instructions.

Amongst other specimens of the products of the *Landes*, under the system of sylviculture adopted, exhibited in the Industrial Museum in Edinburgh, were specimens of wood cut up into galleries by the *Bombyx pytiocampa*, and other lignivorous insects, and specimens of the same restored to healthy growth by a process devised by Dr.

Roberts, with specimens of wood treated by M. Courval for similar defects.

Sect. IV.—*Destructive Ravages occasioned by the Mole.*

Another source of trouble in such plantations of the maritime pine is the subterranean galleries created by the mole. In regard to this M. Boitel writes :

"The mole is to be found everywhere in sand or clay, in dry or damp soil. Its operation seems to be measured by the opposition which the ground makes to its efforts. In light sandy ground it makes very long galleries ; it makes shorter ones where the clay is tenacious. It does not, however, dislike the latter kind of ground ; on the contrary, it prefers it, either on account of the solidity which it confers on the galleries, or on account of the abundance of earth worms in it. Although it can swim, and can easily protect its retreat from water, it does not inhabit low wet places, unless it finds some elevated spot in the midst of the surrounding moisture, such as the edge of a ditch, where it can construct a healthy and convenient nest. It delights in the soil of oases, sometimes found on the edge of bogs, which abound in earth worms. In general it does not care for bare exposed places; it prefers spots sheltered by walls, bushes, or trees. It seems to know instinctively that it is safe where its runs are hidden by vegetation. Moles hidden in the banks of ditches are hopeless to catch. It is easier to catch ten in a field than one under a hedge, or on the wooded banks of a ditch.

"The mole is remarkably watchful and active. Its hearing is very acute, although its ears are hardly visible amidst its fur. It is frightened by the least noise. The mole-catcher, or the dog that wishes to capture it, must walk very gently else it will instantly disappear. It sees perfectly with eyes no larger than the head of a pin. It does not fear water, and can swim in order to reach a desired point. This explains how gardens surrounded with water are not exempt from its ravages. It is a solitary animal when adult. It is said that the female drives away the male from her nest. Moles only pair at one season, when two may sometimes be caught in the same trap. The female takes care of her brood for some time. With these exceptions the mole is eminently solitary. I have tried in vain to induce two moles of different sexes to live in a box filled with earth. They fought continually, and there was no peace until one was killed and partly eaten. The male wars against every in-

truder, and fights to the death with other moles, also with weasels and field mice. It is uncommon that both combatants survive. The weasel ever falls a victim.

"Besides the runs and ordinary mole-hills, moles make large heaps of earth, under which are a kind of special nest, measuring from 0·15 mètres, to 0·20 mètres across.

"These are made of the leaves of trees, dry grass, and the green leaves of cereals or other plants within their reach. When they can make a selection they prefer the withered leaves of the oak. They do not, as some say, pull down grass by the roots. They always put out their snouts to collect materials for their nests. They are wise enough to bring their materials from a distance for fear of discovering their retreat, especially when they cut down green corn. It is perfectly proved that everything required for their nests is brought from above ground, and that roots of plants are never made use of.

"What is called improperly the mole's nest is only a warm and comfortable retreat, where it lives permanently and habitually. The males have their nests as well as the females. This habitation is the central point of all its operations, it is the spot most frequently visited. The mole reaches it by all kinds of runs, both horizontal and vertical; it contains its food magazines abundantly supplied with pieces of earth-worms still in life, so as to preserve them for a longer time. This animal, so active and strong in scraping, is never long without visiting its nest, it sleeps and eats there generally. It is often found warm when uncovered by the mattock. The most able mole-catchers have never surprised the mole in its nest. At the first sound they disappear in their deepest and best concealed runs. The nest is often renewed without the position being much changed. Under the same heap of earth may be found three or even four nests of different ages. The same mole has sometimes several central dwellings which it occupies irregularly so as to escape the snares of its enemies. The heap which conceals the nest is always larger than the usual mole heap, they are 0·50 mètres in height, nearly 1 mètre across.

"The nest is not always under one of these large heaps which are so easily seen. Sometimes it is placed under an adjoining ordinary sized hill. The female usually makes use of this ruse so as to conceal her young. Nests placed under very large hills are what mole-catchers call false or male's nests.

"The experienced mole-catcher can easily distinguish the nest of the female, because, not being so strong, they cannot throw up so

much earth, and their mole-hills are smaller and flatter. The mole-hills furnish valuable indications. An experienced man can divine the sex of the animals from the appearance of the mole-hills; amongst the numerous runs they can fix on the chief road between two important centres, and the mole can hardly escape a trap placed where it must be passed a thousand times in a day. From these indications, the mole-catcher can deal with the females and young ones so as to suit his own interest, which he never fails to do when he is paid at so much per head. The female has in the year two litters of four or five each. Young moles produced in spring have a litter before the end of the first year. The first litter is produced in the month of April, and it is of great consequence to catch them at that time, as one mother caught means four or five less on the estate. The real nests can be easily detected, as we have said above.

"I will now point out the best way of getting rid of them. Only a man trained specially will do any good; others will not pursue the moles with the order, regularity, and intelligence necessary. The good mole-catcher knows the habits and instincts of the animal, and that preliminary knowledge will suggest modes of destruction which would escape any other person.

"I am acquainted with one skilful mole-catcher; three times a year he comes from Normandy to work on some of the important estates in Sologne. From his zeal and activity, he seems born for the trade. He undertakes to destroy the moles at so much per head, or so much per hectare. If he receives 25 centimes a head (the usual price), he cares more for the number of his victims that for doing his work thoroughly. He tries to catch males rather than females, who are the hope of the future. On this point I may relate what happened to one of my neighbours with the mole-catcher in question. The first time he was employed, it was fixed that he should receive 25 centimes per mole. At the end of two days he brought eighty-nine moles, of which seventy-two were males. It was evident that the females had been spared. It is better to make arrangements by the quantity of ground. In Sologne 1 franc 50 centimes are given per hectare without food.

"The skilful mole-catcher, when visiting his traps, keeps an attentive eye on the mole-hills and runs. Whenever he sees a mole disturbing the ground, he approaches slowly, with one stamp he intercepts the new run in such a way as to cut off all retreat, and one blow of the mattock secures his victim. The mattock is also used in getting

at the nests with young ones ; and it is used for sounding the earth and finding out runs."

Sect. V.—*Destructive Ravages by Forest Fires.*

M. Eloi Samanos, in his volume entitled *Traité de la Culture du Pin Maritime*, to which reference has been made, remarks : " One of the greatest scourges to which a pine-wood plantation is exposed is beyond contradiction that of fire ; it reaches a height with such facility, and spreads with such fearful rapidity.

" There is preserved in our district (apparently that of Cape Breton) the memory of a fire which devastated our forests, on an extent of from five and twenty to thirty kilomètres; such occurrences may well suffice to create a most reasonable fear in proprietors, and to urge upon them the adoption of the greatest measures of precaution.

" Such occurrences are almost always occasioned by workmen who light fires in the forest without seeing to these being completely extinguished ; they may also be occasioned by storms falling upon a forest, as happened in the imperial domain of Solferino. . . .

" One precautionary measure against fire, adopted by some careful foresters, consists in separating resinous woods by planting broad bands of deciduous trees between them.

" This has been carried out by the intelligent engineer, M. Crouzet, in the imperial domains of Solferino, under his direction, in which he has plantations of deciduous trees dividing the woods of maritime pines. By this means the fury of the fire at least is diminished, and it becomes easy to circumscribe and confine its ravages.

" Besides this, there is one means employed in our district to combat conflagrations, known under the name of *contre-feu*. It is this : when the inhabitants have been congregated on the scene of the disaster, and they judge the extinction of the fire by direct means impossible, they go in the direction in which the fire is advancing, and at some distance from it, having armed themselves with well clothed pine branches, they form in line, and burning there the thorns, heaths, or other dry woods between them and the fire they prevent this fire from spreading in the different directions and smother it ; and this being done, the conflagration, on advancing to that place, finds no food for its continuation, and often dies out."

To rely entirely on such means, M. Samanos considers inexpedient, and he says : " Plantations of deciduous trees ought also to be em-

ployed amongst the precautions taken for the conservation of forests, and it is impossible to do too much to make known and to introduce such a measure."

In accordance with this account of the *contre-feu* is the following statement by M. Bartro, in an article on the maritime pine in the *Adour*, a journal of Bayonne :

"Resin-yielding forests are extremely combustible. Their soil is strewed with ferns, with brooms, and with dried leaves ; it is covered with trunks of trees, which distil resin, drops of which are seen everywhere ; a single spark, or the wadding of a gun, may suffice to set the country on fire. When this misfortune happens the tocsin is sounded in the adjacent communes. The population arm themselves with shovels and hatchets ; they march under the leadership of the mayors, who direct the operations and compose a guard, the duty of which is to work themselves and to prevent desertion by the other workers. They note the wind under which the conflagration spreads, and regulate their procedure accordingly. By this combination of labours the fire finds itself encircled by the population of the different communes, who proceed to extinguish it, and, unless the wind be very strong, and carry the burning flakes behind the workers, in which case they are very much exposed to be themselves surrounded by the fire, they find it pretty easy to master it, and that they do thus :

"The workers, one after another, furnish themselves with green and branching boughs ; they take their place at what is deemed a proper distance in line in front of the advancing fire ; they set fire to the ferns and other combustibles in front of them, which they extinguish, as they progressively advance toward the fire, by smiting them with their green branches, and covering them with earth by means of their shovels. This is what is called making a *contre-feu* When the fire comes it finds no food, and it is forced to go out. This is the only means of which use is made to stop the conflagration in forests of resinous trees."

Boitel, in reference to this, compares it to the homœpathic treatment of disease by physicians acting on the principle—*Like cures Like* —it is fire extinguished by fire, and he goes on to say :

"Forest fires would be less common if the police were less negligent ; if herdsmen, shepherds, resin-collectors, and woodmen did not take pleasure in lighting fires in the heart of the pignadas, or pine

forests, for the most trivial objects, the embers of which they keep constantly glowing to supply them with fire for their pipes, for their *méture*, a preparation of Indian corn, and to broil their salt fish and their sardines, culinary operations which ought to be attended to before leaving their homes. These fires in the open air are left burning on ground covered with combustible matter while the workmen go about their work. Is it surprising then that there should be so many fires?

"Insurance companies bring themselves with difficulty to insure *pignadas*; moreover, they cannot do otherwise than require a high premium, which the greater part of proprietors will not agree to pay.

"The provident cultivator, who wishes to protect his forests against a general conflagration, takes the prudent precaution to interpose in his forest masses cultivated clearings sufficiently large to form a barrier which cannot be overleapt by the destructive scourge. This preventative costs less than the premium of insurance.

"Forest fires occasion more damage in young pineries than in those which are in a state of decadence; for the old trunks are not consumed by the fire, and they have lost nothing of their fitness to yield wood for carpentry work, and the employment of them in this way affords some indemnity to the proprietor; it is otherwise with young pineries, which the fire destroys without giving any compensation."

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